Analysis of Mesoscale Airflow Patterns in the South-Central Coast Air Basin during the SCCCAMP 1985 Intensive Measurement Periods

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ABSTRACT

An analysis of the mesoscale airflow patterns in the south-central coast air basin (SCCAB) was performed using data collected during the 1985 South-Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP). Airflow within the SCCAB is strongly influenced by the diurnal sea-breeze/land-breeze cycle and by slope flows that develop along the steep terrain. Mesoscale airflow features observed during the four intensive monitoring periods include eddies along the coast and over the Santa Barbara Channel. An analysis of the transport patterns indicated that both recirculation of pollutants within the SCCAB and transport of pollutants from the south coast air basin (SOCAB) contributed to the observed high ozone concentrations on the intensive monitoring days.

1. Introduction

Wind data collected during the 1985 South-Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP) were used to analyze the mesoscale airflow patterns in the south-central coast air basin (SCCAB) during four intensive monitoring periods: 12–14 September, 20–21 September, 23–25 September, and 2–4 October. A large number of surface and upper-air monitoring sites were operated during the SCCCAMP and were primarily located within the coastal and offshore areas.

An understanding of the mesoscale airflow patterns is critical to understand ozone episodes in the SCCAB. Since high ozone concentrations were observed in the SCCAB during three of the four intensive monitoring periods, the SCCCAMP data provided the opportunity to improve our understanding of the mesoscale airflow associated with ozone episodes. The large number of monitoring sites provided good spatial and temporal resolution of some mesoscale airflow features. The SCCCAMP wind data are summarized in section 2.

The wind data were analyzed using a diagnostic wind model. Using this model observational wind data are incorporated via weighted interpolation into a first-guess field that consists of a domain-mean wind that has been adjusted for terrain effects. Figure 1 illustrates the complex topography of the SCCCAMP wind analysis domain. The diagnostic wind model is described in section 3.

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A number of interesting airflow patterns was observed during the intensive monitoring periods, including the development of mesoscale eddies along the coast and over the Santa Barbara Channel. The complex mesoscale airflow patterns in the SCCAB govern the transport of ozone and ozone precursors within the region and through its boundaries. Ozone precursor emissions within the SCCAB are concentrated in the Ventura–Oxnard, Santa Barbara, and offshore areas. The south coast air basin (SOCAB), located to the southeast of the SCCAB, is also a potential source of ozone and ozone precursors. Los Angeles is situated within the SOCAB.

Backward particle paths were generated using the analyzed wind fields to assess possible transport of ozone and ozone precursors during the four intensive monitoring periods. The mesoscale airflow patterns and particle path analyses are presented in section 4. The analysis results are summarized in section 5.

2. Wind data

The SCCCAMP wind analysis domain and the locations of the surface and upper-air wind monitoring sites are shown in Fig. 2. Note that the observation density at the surface (especially along the coastline) is much greater than that aloft. The existing meteorological monitoring network in the SCCAB was supplemented to enable the characterization of pollutant transport in the Santa Barbara Channel, coastal areas of Santa Barbara County, and the southern portion of Ventura County (Dabberdt and Viezee 1987). In general, hourly averaged wind data were reported at the surface monitoring sites. The upper-air monitoring network consisted of radiosondes (with measurements

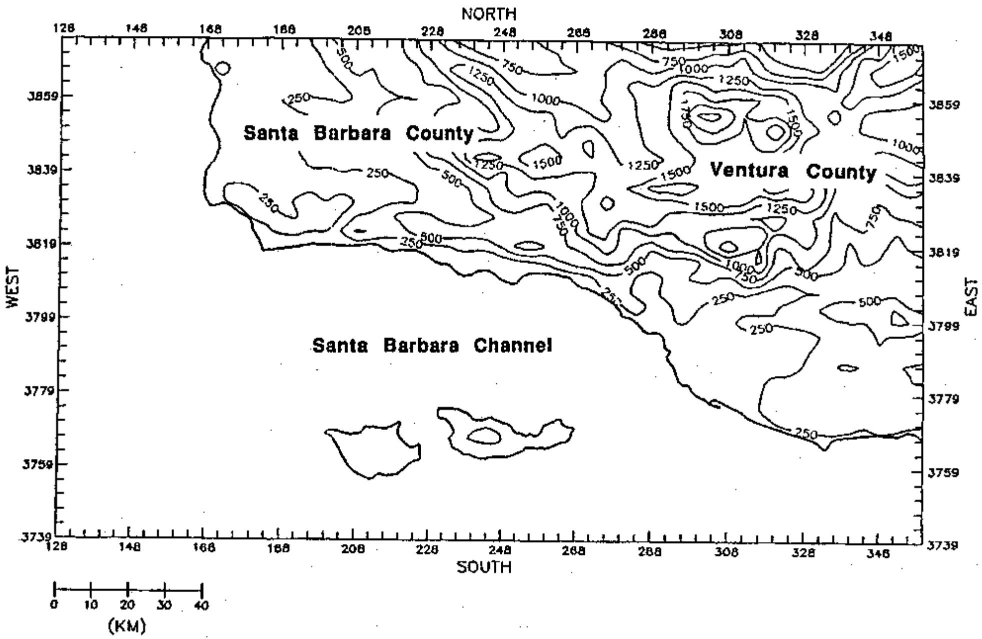


FIG. 1. The SCCCAMP wind analysis domain. The axes are labeled in zone 11 Universal Transverse Mercator (UTM) coordinates. Topography is contoured in meters.

2–4 times daily) and Doppler acoustic sounders (with continuous measurements).

3. Diagnostic wind model

Hourly gridded wind fields were generated for each of the intensive monitoring days using a diagnostic wind model (Kessler et al. 1988). This model incorporates observations where they are available and provides some information on terrain-induced airflows in regions where local observations are absent. The model is formulated in terrain-parallel coordinates. Wind fields are generated using a two-step procedure.

In step 1, a domain-scale mean wind is adjusted for terrain effects. These include the kinematic effects of terrain (the lifting and acceleration of the airflow over terrain obstacles), thermodynamically generated slope flows, and blocking effects. Step 1 produces a spatially varying gridded field of u and v for each vertical layer within the model domain.

Step 2 adds observational information to the (u, v) field calculated in step 1 by using an objective analysis procedure: observations are used within a user-specified radius of influence, while the step 1 (u, v) field is used in subregions where observations are unavailable. The following modified inverse-distance-squared weighting scheme (Ross and Smith 1986) is used for the interpolation of data:

$$(u, v)_2 = \{\sum_k [r_k^{-2}(u_0, v_0)_k] + R^{-2}(u, v)_1\}/(\sum_k r_k^{-2} + R^{-2}) \quad (1)$$

where (u_0, v_0) denotes an observed wind at station k, r_k is the distance from station k to a given grid point, $(u, v)_1$ is the step 1 wind field at the grid point, and $(u, v)_2$ is the updated wind vector. The parameter R controls the relative influence of the observations and the step 1 wind field. The weighting scheme is illustrated graphically in Fig. 3.

Following the interpolation, a 5-point smoother in the form:

$$A'_{i,j} = 0.5A_{i,j} + 0.125(A_{i-1,j} + A_{i+1,j} + A_{i,j-1} + A_{i,j+1}) \quad (2)$$

is applied to the horizontal wind field to reduce the discontinuities that may result from the interpolation. The vertical velocity is calculated by integrating the incompressible conservation of mass equation. Zero-gradient lateral boundary conditions are used.

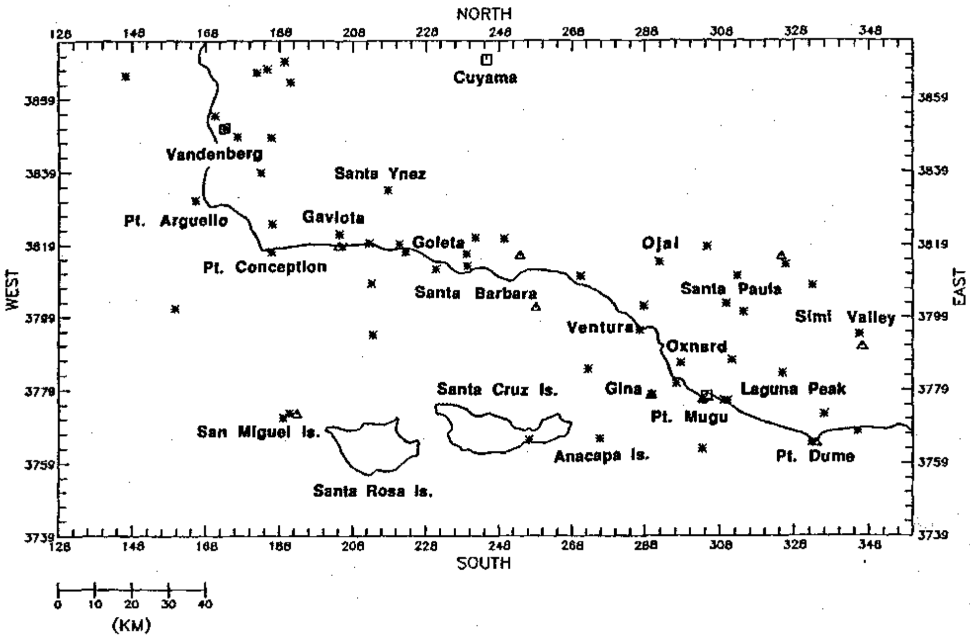


FIG. 2. The SCCCAMP monitoring network. The locations of the surface wind monitoring sites are denoted by asterisks. Upper-air radiosonde site locations are denoted by squares and Doppler acoustic sounder site locations are denoted by triangles.

Generation of the SCCCAMP wind fields involved 1) preprocessing of the wind data for input into the model, 2) specification of model input parameters, and 3) exercise of the diagnostic wind model. Winds were analyzed within each of five vertical layers: 0–20, 20–180, 180–420, 420–780, and 780–1220 m AGL. The nominal analysis levels of 10, 100, 300, 600, and 1000 m AGL referenced in the discussion represent the midpoints of these layers.

In the preprocessing step, the upper-air data were vertically averaged within the model layers and the less-frequent upper-air data were linearly interpolated in time to enhance the temporal consistency of the wind fields and to provide hourly input for the diagnostic wind model.

Maximum radii of influence for the interpolation of data were based on the spatial distribution of observations and were assigned values of 20 km for the surface layer, 50 km aloft, and 200 km over water. The weighting parameter for the terrain effects (R) was set equal to 10 km in the analysis of the surface winds and 25 km in the analysis of the winds aloft. Kessler et al. (1988) discuss the tests that were performed to examine the sensitivity of the diagnostic wind model to the various controlling parameters and to determine the optimum values of these parameters for the SCCCAMP wind analysis.

The diagnostic wind model also requires, as input, domain-mean wind and domain-scale stability information. For this analysis, specification of the hourly domain-mean wind was based upon the Cuyama ra-

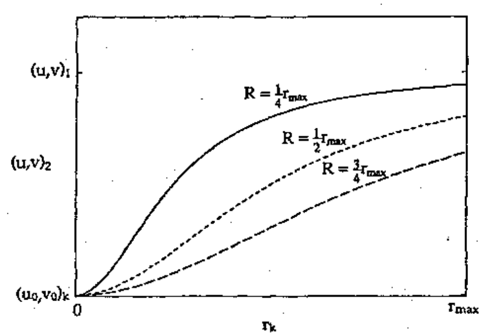


FIG. 3. Graphical illustration of the interpolation scheme for a single observation.

diosounding, which was located at 244.5 easting and 3870.0 northing in Universal Transverse Mercator (UTM) zone 11. Data from this site were selected to represent the wind in the portion of the domain where the first-guess field of the diagnostic wind model was weighted most heavily (the data-sparse interior). Similarly, the specification of the domain-mean lapse rate was based on the Cuyama sounding. Since this station is located well inland, it is unlikely that it is influenced by the advection of maritime lapse rates.

The accuracy that the diagnostic wind model represents the wind field at a given grid point depends upon nearby wind observations, the terrain-adjusted wind field at that grid point, and the radius of influence and other controlling parameters. Experiments demonstrating the accuracy of the diagnostic wind model are described by Kessler et al. (1988).

4. Intensive monitoring periods

This section contains an overview of the synoptic-scale meteorology, an analysis of the mesoscale airflow patterns, a summary of the ozone air quality, and an examination of possible transport patterns for each of the intensive monitoring periods. A comprehensive summary of the synoptic-scale meteorology during SCCCAMP 1985 is given by Viezee et al. (1987). Detailed descriptions of the mesoscale airflow patterns are provided by Kessler et al. (1988). An overview of the ozone air quality during the intensive monitoring periods is given in Table 1.

In this section the airflow patterns are illustrated by plots of the analyzed wind fields at 1500 PDT for the surface layer (10 m AGL) and layer 3 (300 m AGL).

a. 12–14 September

1) SYNOPTIC OVERVIEW

Eastward movement of the Pacific high and advection of warm air into southern California by a hurricane located southeast of Baja California resulted in significant warming of the troposphere on 12 September. Building high pressure at the surface produced subsidence and inversion conditions within the SCCAB. This warming did not continue into 13 September because of the development of a low pressure trough along the West Coast and a retreat westward of the Pacific high. Weak pressure gradients and light winds characterized the SCCCAMP study area. A cold front associated with the low pressure system off the coast of Washington was approaching from the north. On 14 September the low pressure system weakened and moved inland while northwesterly winds began developing along the California coast.

2) MESOSCALE AIRFLOW PATTERNS

Diagnostic analyses of the airflow patterns for 12–14 September at the surface and 300 m AGL are presented in Figs. 4–6.

The airflow within the SCCAB during the morning of 12 September was characterized both at the surface and aloft by offshore-directed drainage and downslope flow along the coast, northeasterly flow over the inland portion of the domain, and northwesterly flow in the southwestern part of the domain. During the early morning hours, winds over the central Santa Barbara Channel were calm.

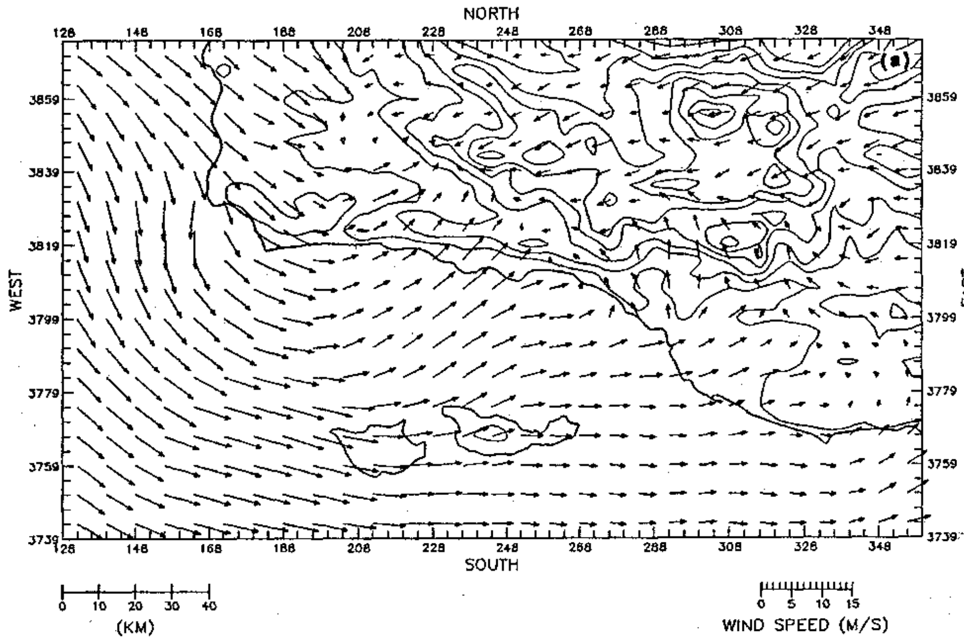
A sea breeze developed along most of the coastline by 1200 PDT, persisted through 1800 PDT, and penetrated inland as far as 50 km. The analysis of sea-breeze penetration may be limited by lack of available data in areas far removed from the coastline. The 1500 PDT surface analysis (Fig. 4a) illustrates the extent of sea-breeze penetration. Western Santa Barbara County, Ojai, and the Oxnard plain are under the influence of the sea breeze.

A common feature of the airflow in the SCCAB is the persistent northwesterly flow along the western edge of Santa Barbara County. Curvature effects introduced by the coastal curvature in the vicinity of Point Arguello/Point Conception often combine with onshore/upslope flow along the Santa Barbara coast to form an eddy in the Gaviota area. This eddy, frequently referred to as the Gaviota eddy (Smith et al. 1983), is indicated in the 1500 PDT surface analysis. A weaker sea breeze with less inland penetration than at the surface is indicated at 300 m AGL (Fig. 4b). Winds at this level were weaker in many areas.

During the evening of 12 September, onshore flow at the surface was gradually replaced by nocturnal drainage flow. This offshore-directed flow was somewhat weaker than on the previous day. North-northwest winds persisted in the western portion of the anal-

TABLE 1. Overview of ozone air quality during the SCCCAMP intensive monitoring periods.

Period	Peak ozone concentration (pphm)	Peak concentration time (end hour)	Peak concentration location
12–14 September	19.2	1500 PDT 13 September	Laguna Peak
20–21 September	9.5	1400 PDT 21 September	Castro Peak
23–25 September	23.0	1600 PDT 24 September	Goleta
2–4 October	20.5	1600 PDT 3 October	Platform Gina



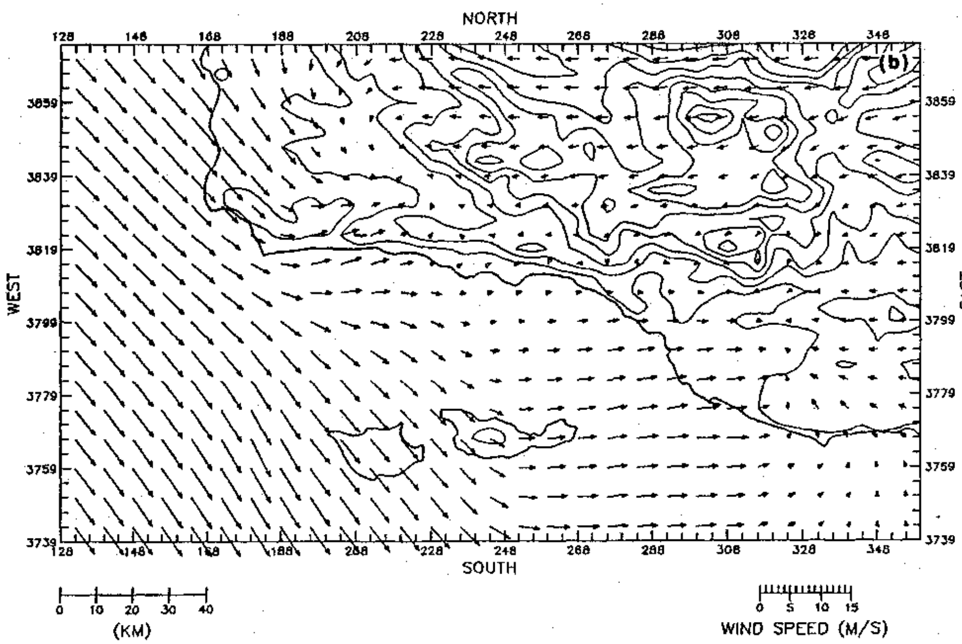


FIG. 4. Diagnostic wind fields for 1500 PDT 12 September 1985 at (a) 10 m AGL, and (b) 300 m AGL.

ysis domain throughout the night. At 300 m AGL, the morning airflow was characterized by easterly flow throughout much of the domain, with southeasterly flow over midchannel, and northerly flow in the western part of the domain.

Sea-breeze development on 13 September was similar to that on 12 September, but with greater inland penetration. The 1500 PDT surface analysis (Fig. 5a) shows that the influence of the sea breeze extended to Simi Valley in Ventura County. A partial Gaviota eddy is indicated on this day. The extent of the onshore flow at 300 m AGL was also greater on 13 September especially in Ventura County (Fig. 5b). The depth of the sea breeze appears to have exceeded 600 m (Kessler et al. 1988). The alongshore component of the flow intensified throughout the remainder of the afternoon both at the surface and aloft.

The retreat of the sea breeze and the development of nocturnal drainage flow on the evening of 13 September resulted in offshore-directed flow and a convergence zone in midchannel during the morning of 14 September. The 300-m AGL wind field was characterized by southeasterly flow over the channel and northwesterly flow in the western portion of the domain.

Strong sea-breeze development occurred in Ventura County and along the western end of Santa Barbara County on the afternoon of 14 September. In the Santa Barbara area, the 1500 PDT surface analysis (Fig. 6a) indicates a sharp offshore convergence zone that was formed by strong northwesterly flow in the Gaviota area (apparently an extension of the sea breeze from the western end of Santa Barbara County), southwesterly flow to the north of Santa Rosa Island, and southeasterly flow just southwest of Santa Barbara. In Ventura County the inland penetration of the sea-breeze front appears to be more rapid than on the previous two days affecting both Simi Valley and Ojai by 1000 PDT. The effects of the synoptic forcing are clearly seen at 300 m AGL (Fig. 6b), which was characterized by strong northwesterly flow in the western half of the domain and primarily westerly flow in the eastern half of the domain.

3) Ozone air-quality summary

No exceedances of the National Ambient Air Quality Standard (NAAQS) for ozone, 12 parts per hundred million (pphm), were recorded on 12 September. The warming of the troposphere on this day was associated with increasing ozone and a maximum concentration of 10 pphm at South Mountain. Ozone levels rose sharply on 13 September in both counties but especially in Ventura County. The maximum concentration recorded on this day was 19 pphm at Laguna Peak. A decrease in ozone concentrations was observed on 14 September, but ozone levels remained high at some high-elevation sites.

4) Transport patterns

Backward particle paths were calculated to examine the possible transport of ozone and ozone precursors within the SCCAB. The particle paths were calculated by first interpolating the analyzed wind fields to the particle position, advecting the particle backward in time for a given time interval, and then integrating the distance traveled by the particle during each time interval. A time interval equal to 15 min was used. To illustrate possible transport patterns during the intensive monitoring periods, backward particle paths were calculated for selected monitoring sites for a 12-h period ending with the hour that the peak ozone concentration was recorded at the site. The backward particle paths were calculated for the surface layer (10 m AGL) and layer 3 (300 m AGL). The two-dimensional particle paths do not incorporate vertical motion, which may be a source of error considering the mesoscale regimes present in the study area.

Backward particle paths for the 12–14 September intensive study period are presented in Fig. 7. The highest ozone concentrations for this intensive monitoring period occurred on 13 September in Ventura County. Five sites within Ventura County were selected for the calculation: Castro Peak, Simi Valley, Laguna Peak, South Mountain, and Santa Paula. Maximum ozone concentrations and peak concentration times (hour end) for each of the monitoring sites are given in Fig. 7a.

The surface-layer particle paths (Fig. 7a) indicate that particles arriving at Santa Paula, South Mountain, and Laguna Peak at 1500 PDT on 13 September were positioned over the Santa Barbara Channel 12 h earlier. Particles arriving at Castro Peak at 1400 PDT and Simi Valley at 1500 PDT appear to have been recirculated by the diurnal land-breeze/sea-breeze cycle. The particles were carried offshore during the early morning hours and returned to shore with the sea breeze, which developed between 900 and 1000 PDT along the Ventura coast. The surface-layer particle paths suggest that intrabasin transport from sources both onshore and offshore may have contributed to the high ozone concentrations observed in Ventura County on 13 September.

At 300 m AGL (Fig. 7b), the backward particle paths indicate possible interbasin transport from the SOCAB via an overwater route. Observed high ozone concentrations at elevated monitoring sites support upper-level ozone transport. Pollutants transported aloft may be mixed down to the surface through convective mixing.

b. 20–21 September

1) Synoptic overview

Synoptic-scale conditions on 20 September were characterized by building high pressure over the eastern Pacific, subsidence and warming of the lower tropo-

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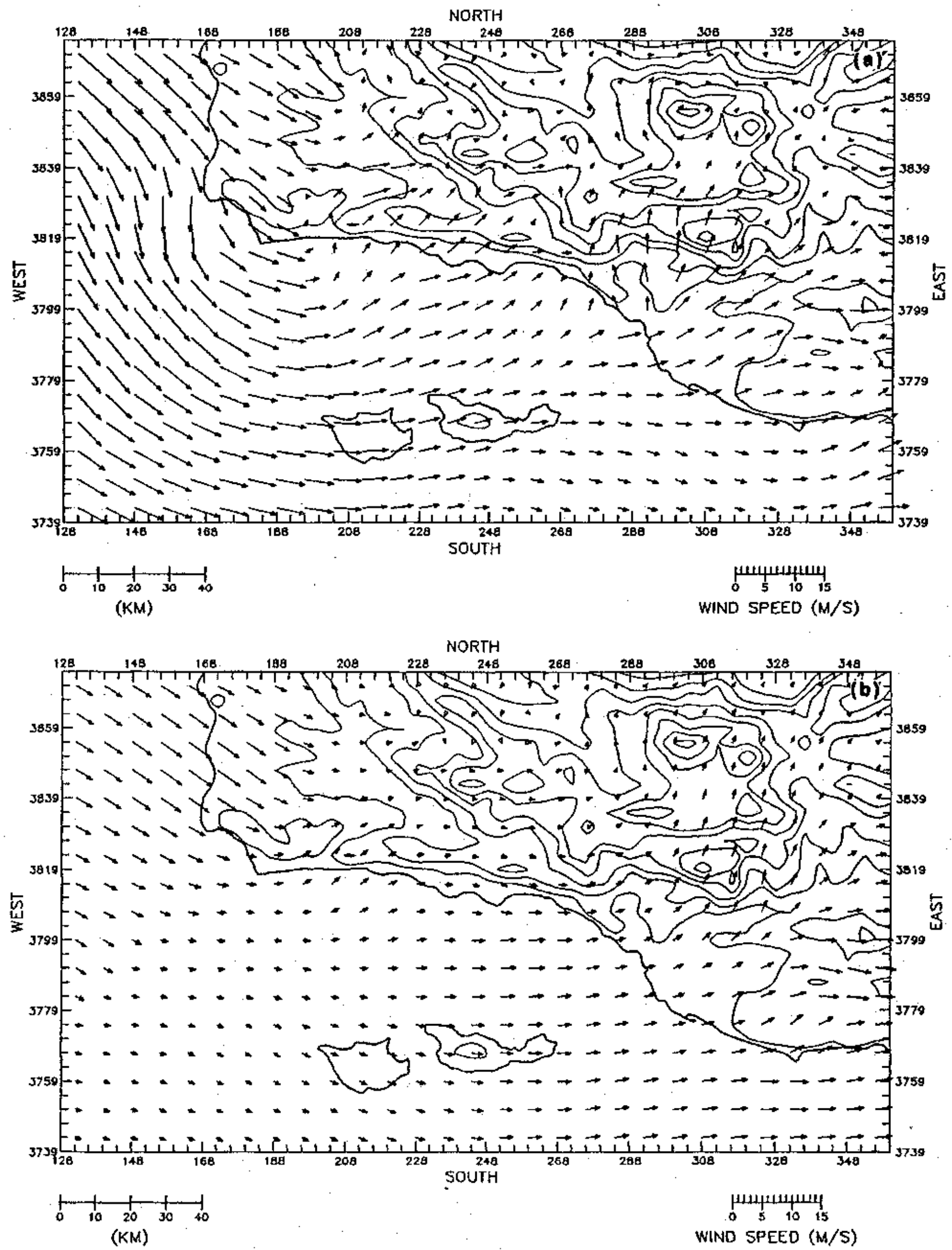


FIG. 5. As in Fig. 4, but for 13 September 1985.

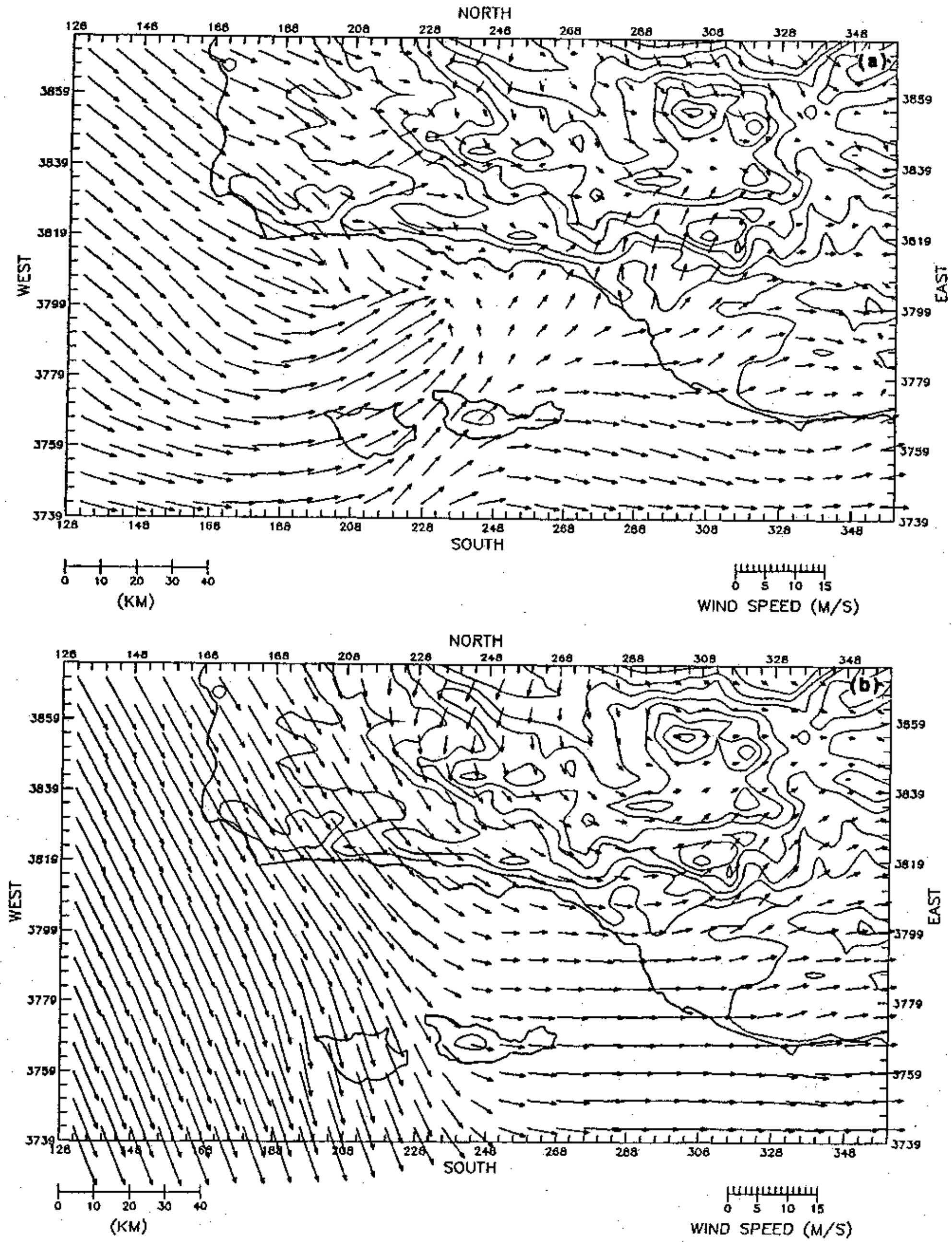


FIG. 6. As in Fig. 4, but for 14 September 1985.

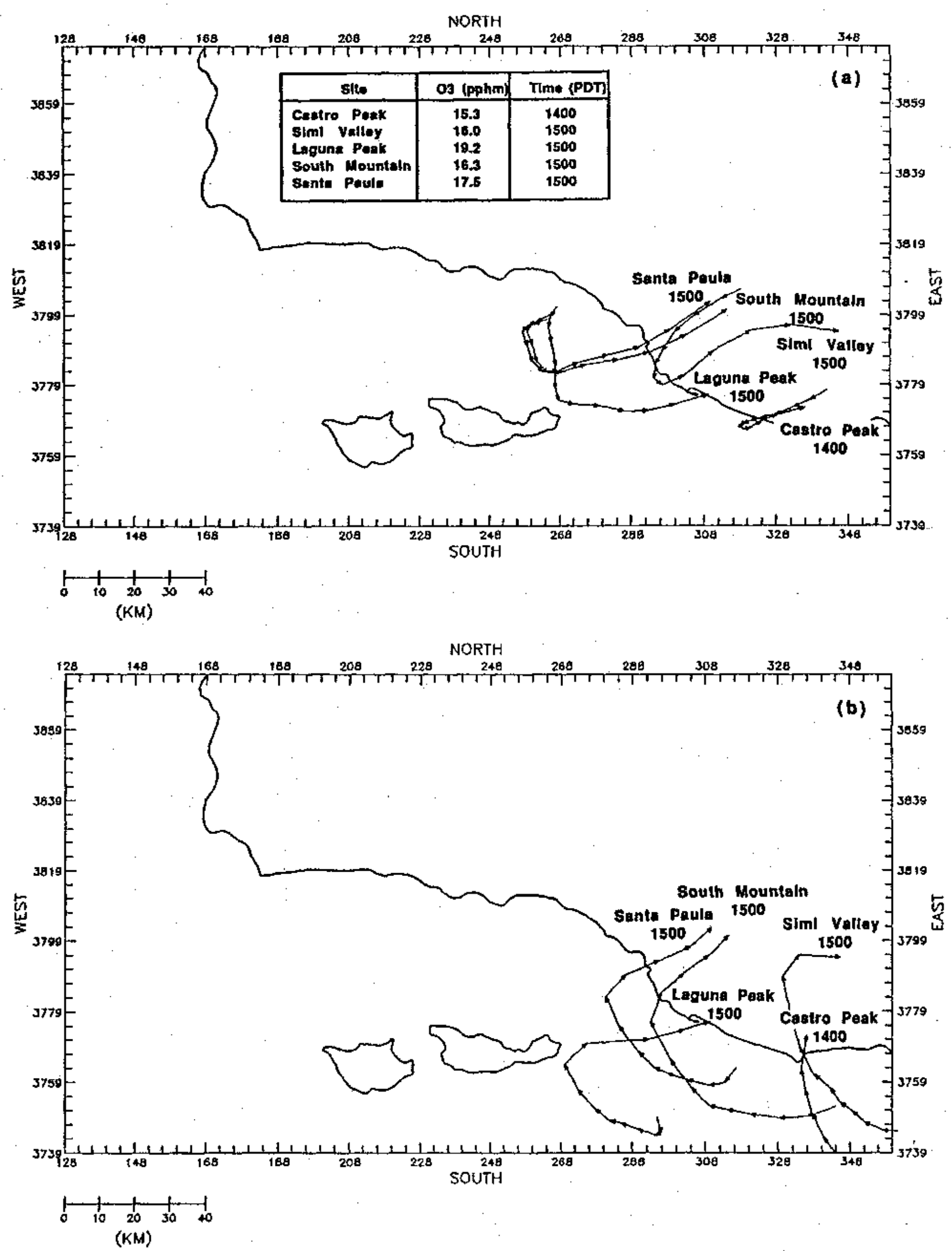


FIG. 7. Backward particle paths for 13 September 1985 at (a) 10 m AGL and (b) 300 m AGL. The particle paths were calculated using the diagnostic wind fields. Maximum ozone concentrations and peak concentration times are given for each of the receptor sites.

sphere, and strong inversion conditions. Conditions were favorable for the development of an ozone episode, but a cold-air outbreak from Canada on 21 September, combined with persistent low pressure over southern California at 500 mb, halted the development of conditions favorable for high oxidant concentrations in the SCCAB (Viezee et al. 1987).

2) MESOSCALE AIRFLOW PATTERNS

Diagnostic analyses of the airflow patterns for 20–21 September at the surface and 300 m AGL are presented in Figs. 8 and 9.

Surface analyses for the morning of 20 September indicate northeasterly flow inland, weak drainage winds along the coast, and numerous zones of convergence and divergence over the channel. At 0300 PDT convergence is indicated off the coast near Ventura and to the southwest of Point Dume. Eddy development is indicated over the western channel between 0500 and 0900 PDT until the onset of the sea breeze at approximately 0900 PDT. Winds aloft were primarily northerly, with easterly flow emerging in the southeastern corner of the domain. This easterly flow intensified, propagated westward, and veered south throughout the morning. Superposition of northwesterly flow in the western half of the domain and southeasterly–southerly flow in the eastern half of the domain produced an eddy that was positioned over the Santa Barbara Channel between 0900 and 1200 PDT.

The 1500 PDT surface analysis (Fig. 8a) shows a well-developed sea-breeze regime. Sea-breeze penetration of up to 50 km inland is indicated in both Ventura and western Santa Barbara counties. The presence of the Gaviota eddy is indicated. The depth of the sea breeze exceeded 300 m over Ventura County during the afternoon of 20 September (Fig. 8b) and contributes to the formation of an eddy over western Ventura County.

The retreat of the sea breeze and the subsequent development of drainage/downslope flow along the coast of Santa Barbara County lead to reformation of an eddy in the western Santa Barbara Channel by 0300 PDT 21 September. At 300 m a transition from northwesterly to northerly to easterly flow over the channel occurred overnight and may have contributed to the eddy development.

The surface-layer eddy propagated eastward and dissipated with the onset of the sea breeze, which occurred at approximately 0900 PDT. On the afternoon of 21 September, the marine air penetrated inland to Santa Ynez and Ojai by 1200 PDT and to Simi Valley by 1400 PDT (Fig. 9a). Alongshore (westerly) flow developed at 300 m AGL by 1200 PDT and intensified throughout the afternoon (Fig. 9b).

3) OZONE AIR-QUALITY SUMMARY

No exceedances of the NAAQS for ozone were recorded in the SCCAB on 20 or 21 September.

4) TRANSPORT PATTERNS

Analysis of this intensive monitoring period provides the opportunity to examine meteorological conditions that do not lead to high ozone concentrations in the SCCAB. On 21 September, ozone concentrations near 9 pphm were found throughout the region.

Backward particle paths were calculated for monitoring sites Castro Peak, Laguna Peak, West Cassitas Pass, LaCumbre Peak, and Exxon B and are presented in Fig. 10. Maximum ozone concentrations and peak concentration times (hour end) for the monitoring sites are given in Fig. 10a. Castro Peak and West Cassitas Pass experience maximum concentrations at 1400 PDT, Laguna Peak at 1500 PDT, Exxon B at 1900 PDT, and LaCumbre Peak at 2100 PDT. The lateness of the latter maxima indicates that some transport may have occurred.

Within the surface layer (Fig. 10a) particles arriving at the four coastal sites appear to have been advected alongshore and then onshore. At LaCumbre Peak, located approximately 15 km inland, advection from the northeast is indicated. The layer-3 particle paths (Fig. 10b) illustrate the effect of northerly flow inland and westerly flow over the channel. The particle paths for this intensive monitoring period indicate that the advection of clean air from the north and from over the ocean is associated with this nonexceedance day.

c. 23–25 September

1) SYNOPTIC OVERVIEW

Synoptic-scale conditions on 23 September were characterized by weak gradients and light winds both at the surface and aloft. Warming of the lower troposphere was observed on this day with the 850-mb temperature reaching 19°C. This warming trend continued into 24 September, and can be attributed to warm air advection produced by high pressure inland and a tropical depression located south of the area of interest. Both the Vandenburg and Point Mugu soundings indicate strong low-level subsidence inversions on 24 September. By 25 September the low pressure center off the coast had moved to a position southwest of the SCCAB, and the airflow shifted from the southeast to southwest. Cooling of the lower troposphere occurred.

2) MESOSCALE AIRFLOW PATTERNS

Diagnostic analyses of the airflow patterns for 23–25 September at the surface and 300 m AGL are presented in Figs. 11–13.

Weak drainage flow, light winds over the Santa Barbara Channel, and north-northwest winds in the western portion of the domain characterized the surface-layer wind fields in the SCCAB on the morning of 23 September. At 0300 PDT, a partial eddy is indicated in the western channel. The 300-m AGL analysis for this time shows easterly–northeasterly flow over the

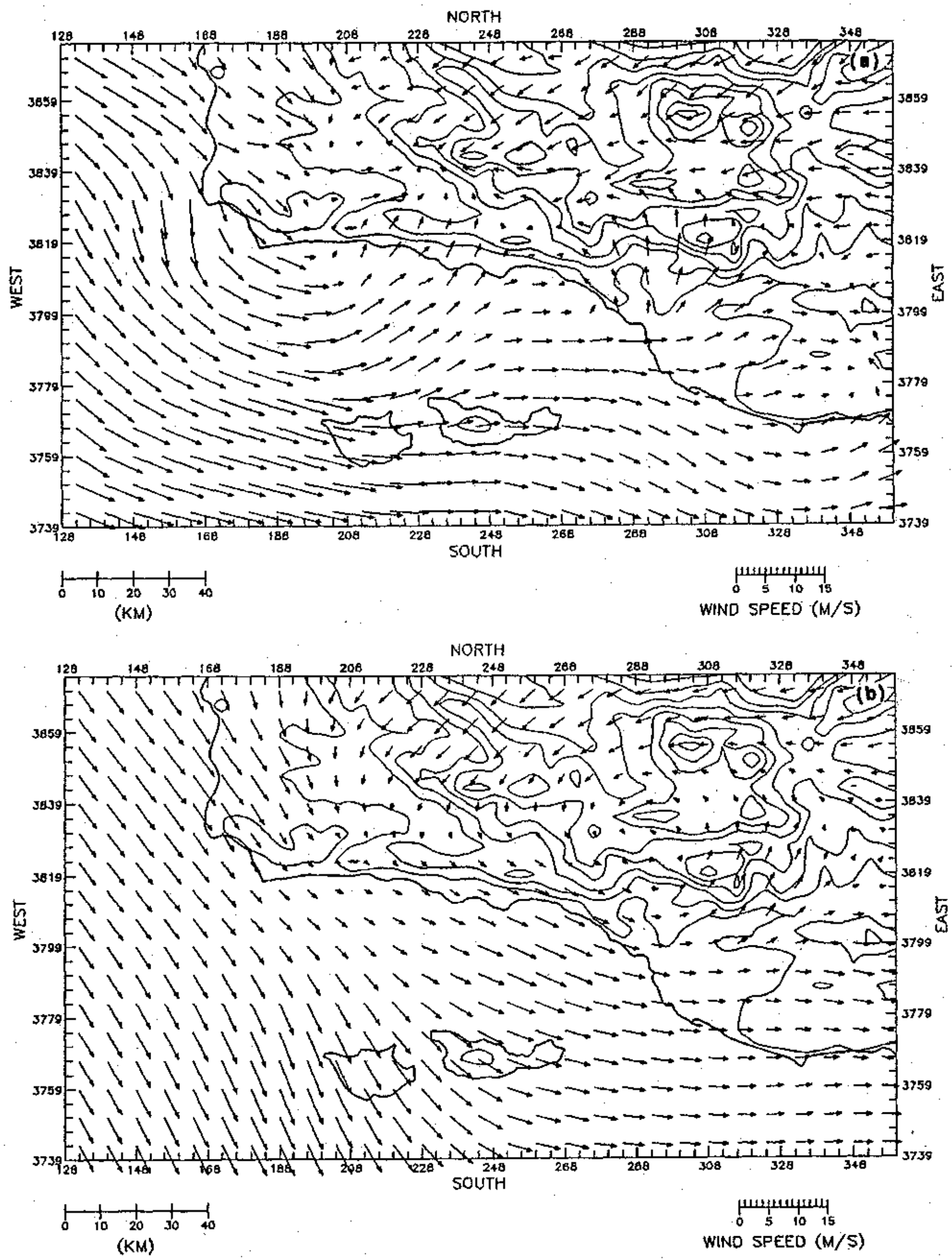


FIG. 8. As in Fig. 4, but for 20 September 1985.

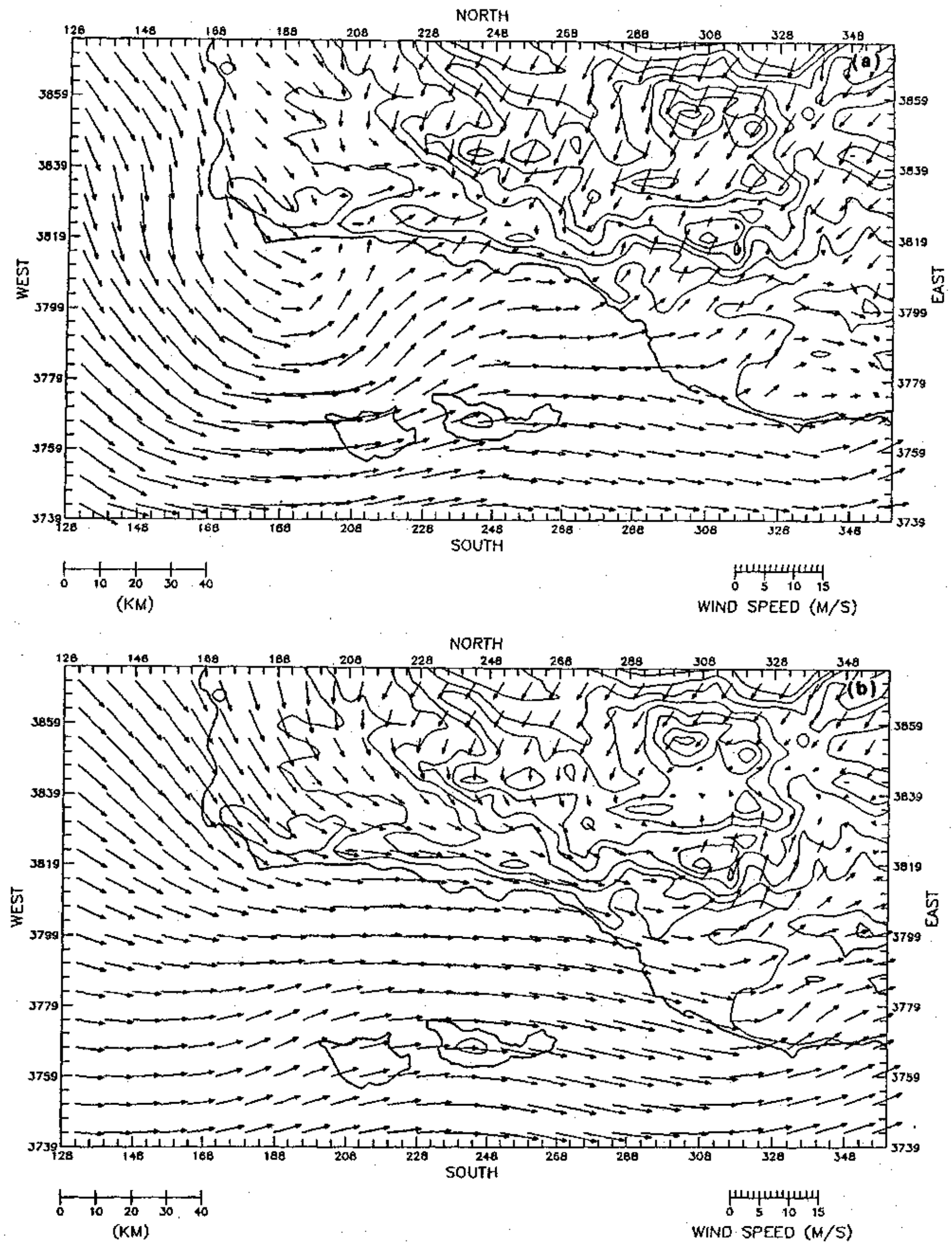


FIG. 9. As in Fig. 4, but for 21 September 1985.

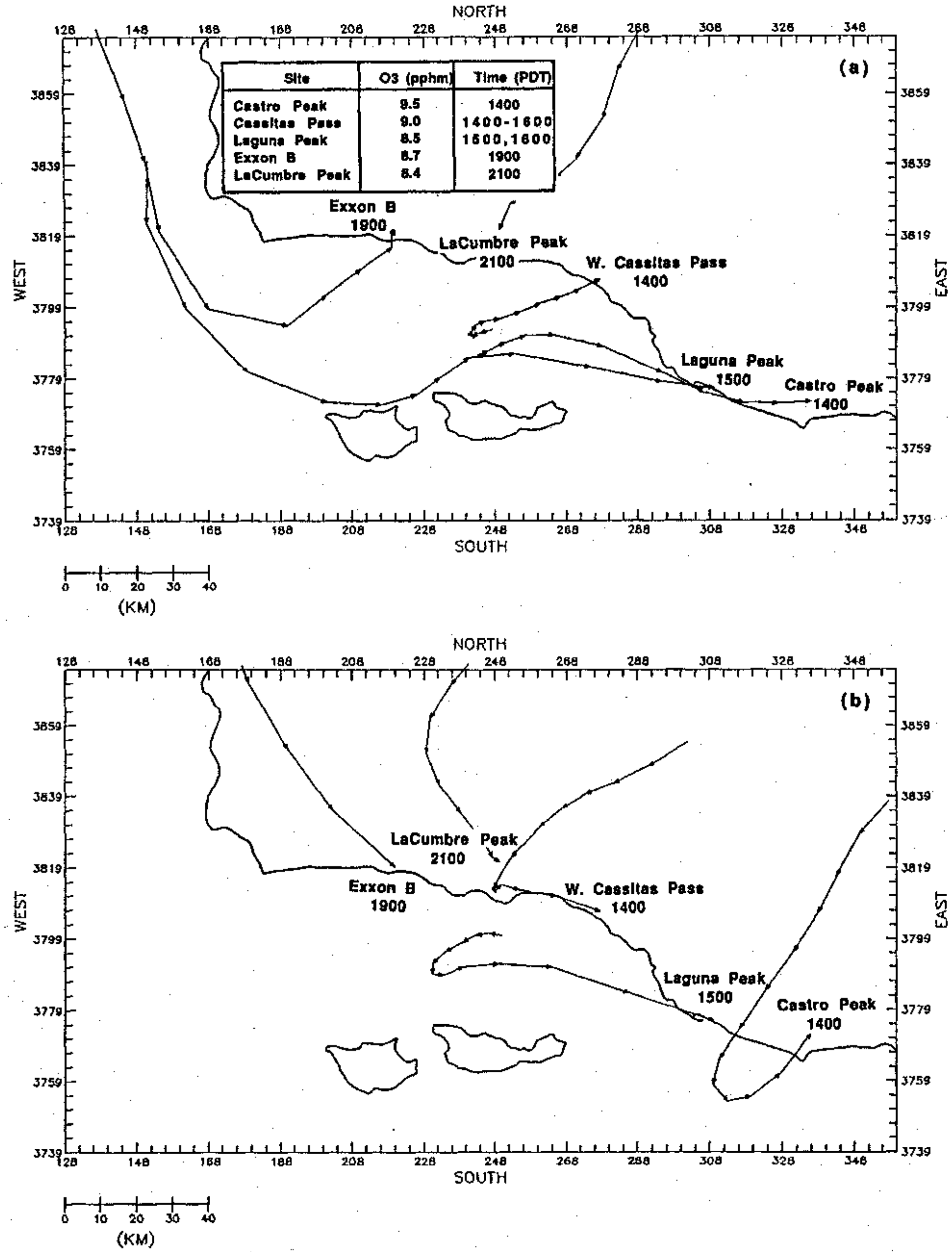


Fig. 10. As in Fig. 7, but for 21 September 1985.

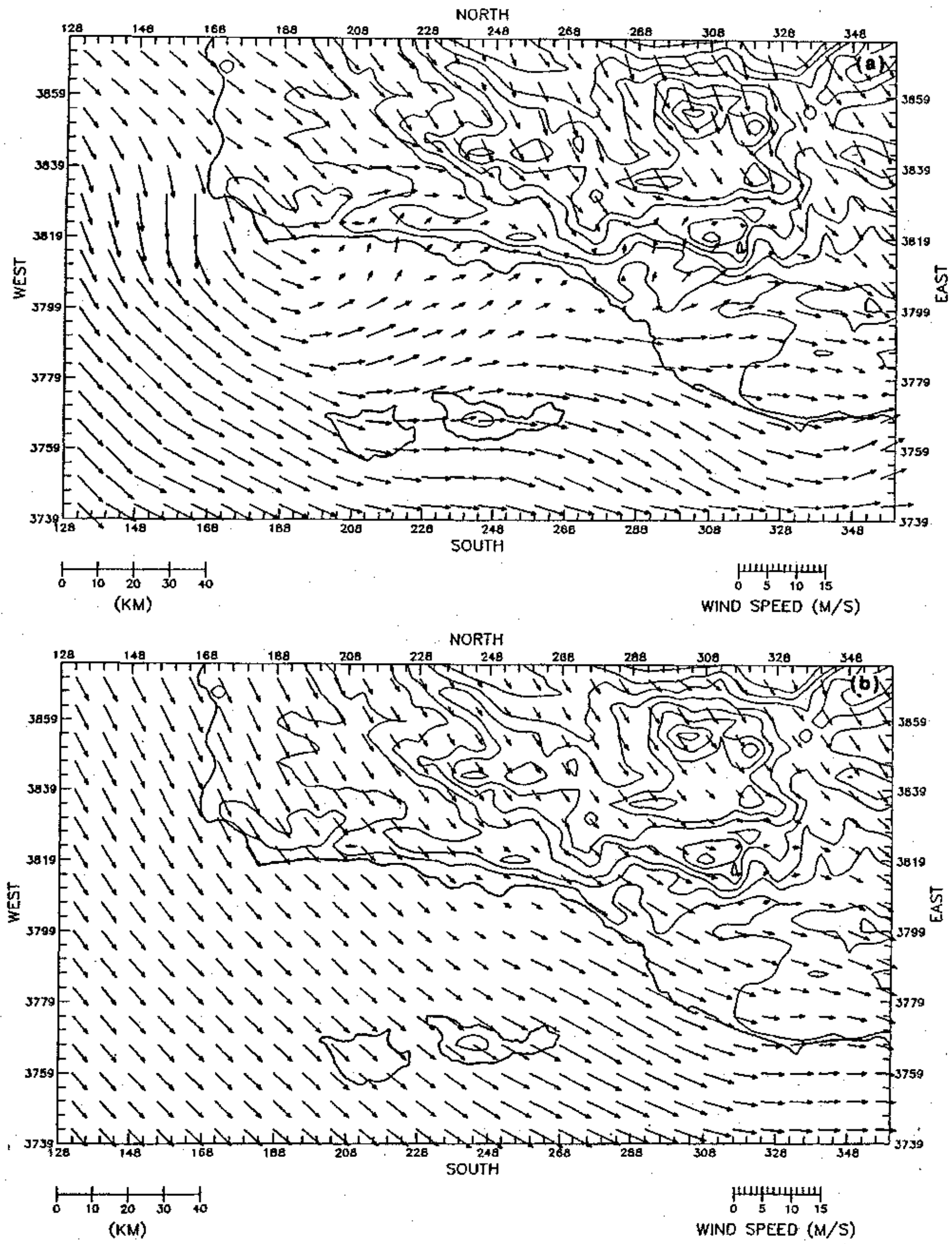


FIG. 11. As in Fig. 4, but for 23 September 1985.

eastern two-thirds of the domain and northerly–northwesterly flow over the western part of the domain.

The sea-breeze regime began to develop by 0800 PDT. This was indicated at the surface by onshore flow and a partial eddy along the coast near Gaviota. The 1500 PDT surface analysis (Fig. 11a) shows significant sea-breeze penetration that is assisted by northwesterly flow inland. Aloft the transition to westerly/alongshore flow began at approximately 1200 PDT. By 1500 PDT (Fig. 11b) northwesterly flow dominated the 300-m wind field.

The surface-layer airflow patterns for the evening of 23 September indicate northeasterly flow inland, retreat of the sea breeze and development of downslope/drainage flow along the coast, and mesoscale eddy development over the channel. During the morning of 24 September, winds over the channel were light with a northerly component. At 300 m AGL easterly flow developed in the southeastern corner of the domain before 0000 PDT and propagated northward and westward reaching the western domain boundary at 0600 PDT.

During the afternoon of 24 September the airflow within the SCCAB was influenced by a tropical depression located to the south of the study area. At the surface southerly flow began to develop over the channel before 1200 PDT and by 1500 PDT extended well inland, suggesting a modified sea breeze (Fig. 12a). Northwesterly flow persisted along the west coast of Santa Barbara County forming a convergence zone between southerly and northwesterly flow in the southwestern portion of the domain. The airflow over the western channel was strongly divergent. Aloft the flow also veered toward the south during the late morning and early afternoon and by 1500 the 300-m AGL airflow over the channel was southerly (Fig. 12b). Easterly flow persisted over land and northwesterly flow (guided by the upper-air observation at Vandenberg) continued in the northwestern corner of the domain.

Subsequent analyses indicate that the development of drainage flow along the coast confined the southerly flow at the surface to the southernmost portion of the domain overnight while southeasterly flow continued at the 300-m AGL level. The convergence zone in the southwestern part of the domain persisted at the surface.

Southerly–southeasterly flow was reestablished over the channel by 1200 PDT on 25 September and by 1500 PDT (Fig. 13a) encompassed much of the domain. Southeasterly flow continued at 300 m AGL (Fig. 13b), although winds in the eastern half of the domain became southerly.

3) OZONE AIR-QUALITY SUMMARY

Ozone concentrations within the SCCAB were relatively high on 23 September, with a peak concentration of 13 pphm. On 24 September ozone levels increased sharply, and numerous exceedances of the NAAQS for ozone were recorded in both Santa Barbara and Ventura counties. On this day a peak ozone concentration of 23 pphm was recorded at Goleta.

4) TRANSPORT PATTERNS

Easterly and southerly winds along the southeastern boundary of the analysis domain and time-staggered northwestward-moving ozone maxima on 24 September suggest that transport from the SOCAB to the SCCAB occurred on this day. Backward particle paths were calculated for South Mountain, Ojai, Santa Barbara, Goleta, and Santa Ynez and are presented in Fig. 14. Maximum ozone concentrations and peak concentration times (hour end) are given in Fig. 14a. Peak concentrations were recorded at South Mountain, Ojai, and Santa Barbara at 1500 PDT; at Goleta at 1600 PDT; and at Santa Ynez at 1700 PDT.

Surface-layer particle paths (Fig. 14a) arriving at South Mountain and Ojai at the peak concentration times were positioned over southern Ventura County 12 h earlier. They were carried offshore and then back onshore with the southerly flow. The particle for Santa Barbara originated in western Ventura County 12 h earlier and was carried offshore and then northwestward along the coast. Particles arriving at Goleta and Santa Ynez at peak concentration times were advected inland from over the Santa Barbara Channel.

At 300 m AGL particle paths for 24 September (Fig. 14b) clearly indicate transport from the east and south. The orientation of the particle paths suggest that westward transport of ozone and precursor pollutants during the early morning hours may have contributed to high ozone concentrations in Santa Barbara county. As the wind shifted to the south during the afternoon, monitoring sites in Ventura County may have experienced additional transport from the SOCAB via an overwater route. Aircraft observations confirm that high ozone concentrations were found within the 200–400 m AGL layer over southeastern Ventura County and offshore during the afternoon of 24 September.

d. 2–4 October

1) SYNOPTIC OVERVIEW

Intrusion of the Pacific high into the northwestern United States and its subsequent southward movement on 2 October generated northeasterly flow aloft along the coast of California. At the surface a deep thermal trough dominated over the state. The Vandenberg sounding indicated strong low-level inversion conditions in the SCCAB. Warming of the lower troposphere continued into 3 October. A low-pressure system located to the west of Baja California may have affected the airflow in the SCCAB. On the following day this

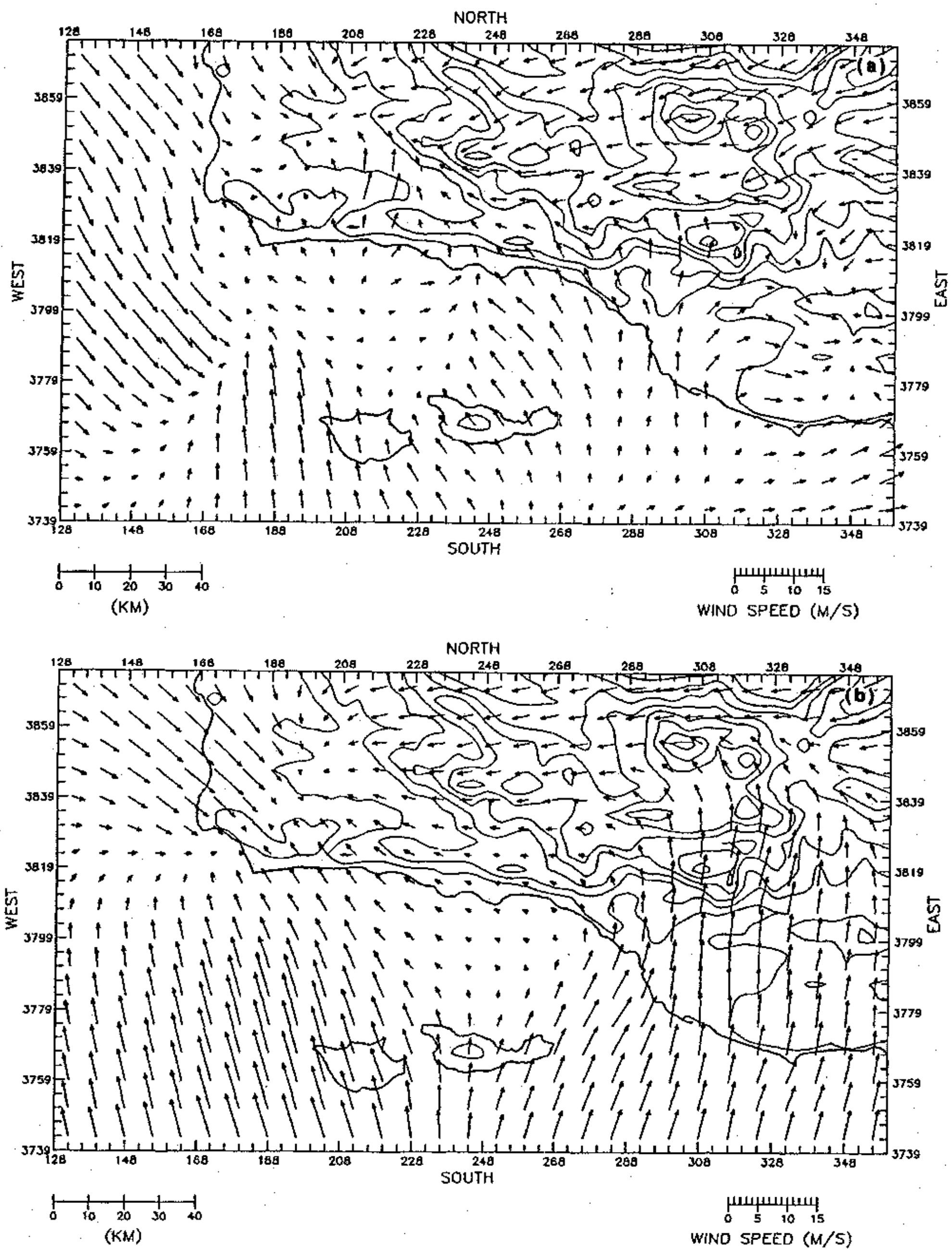


FIG. 12. As in Fig. 4, but for 24 September 1985.

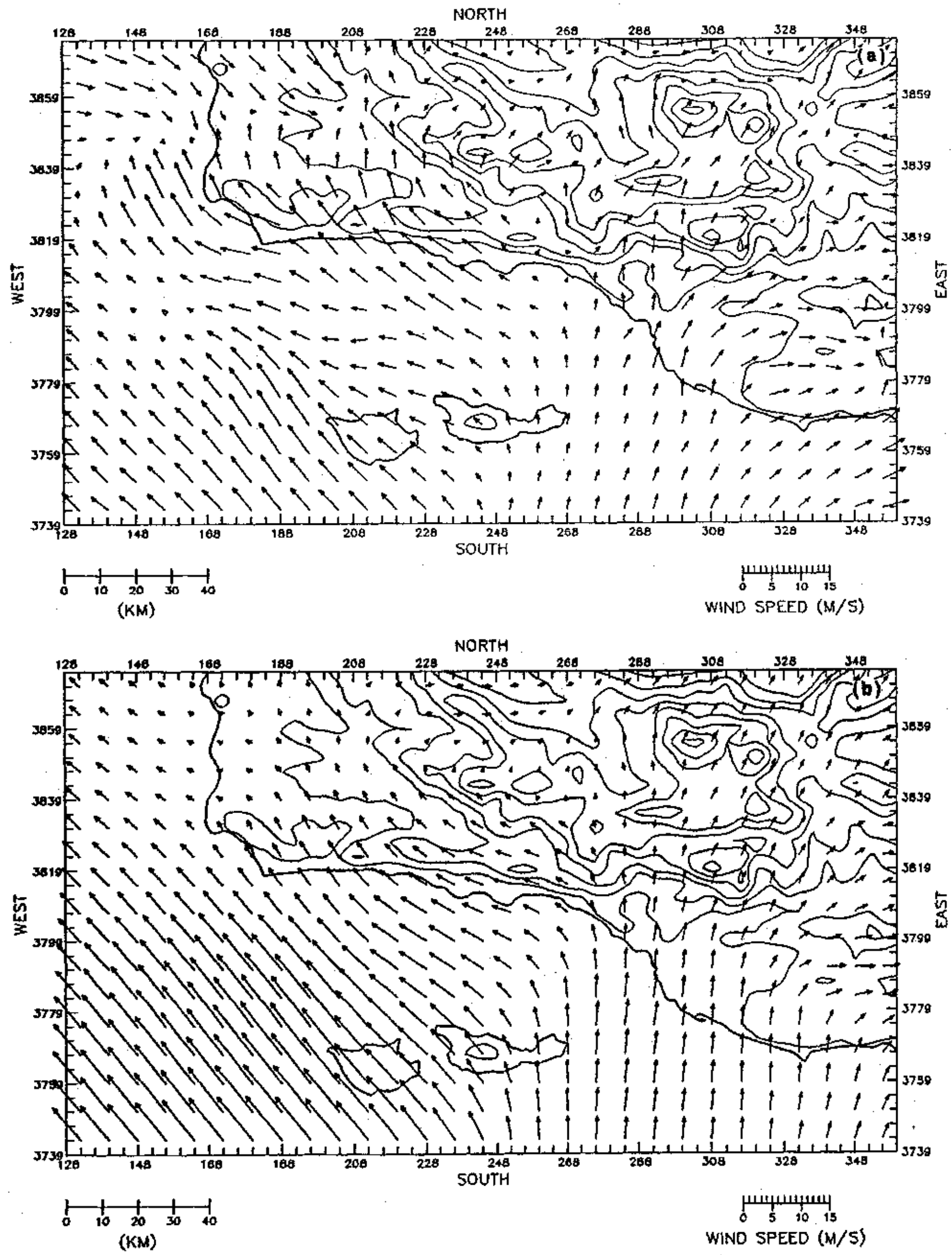
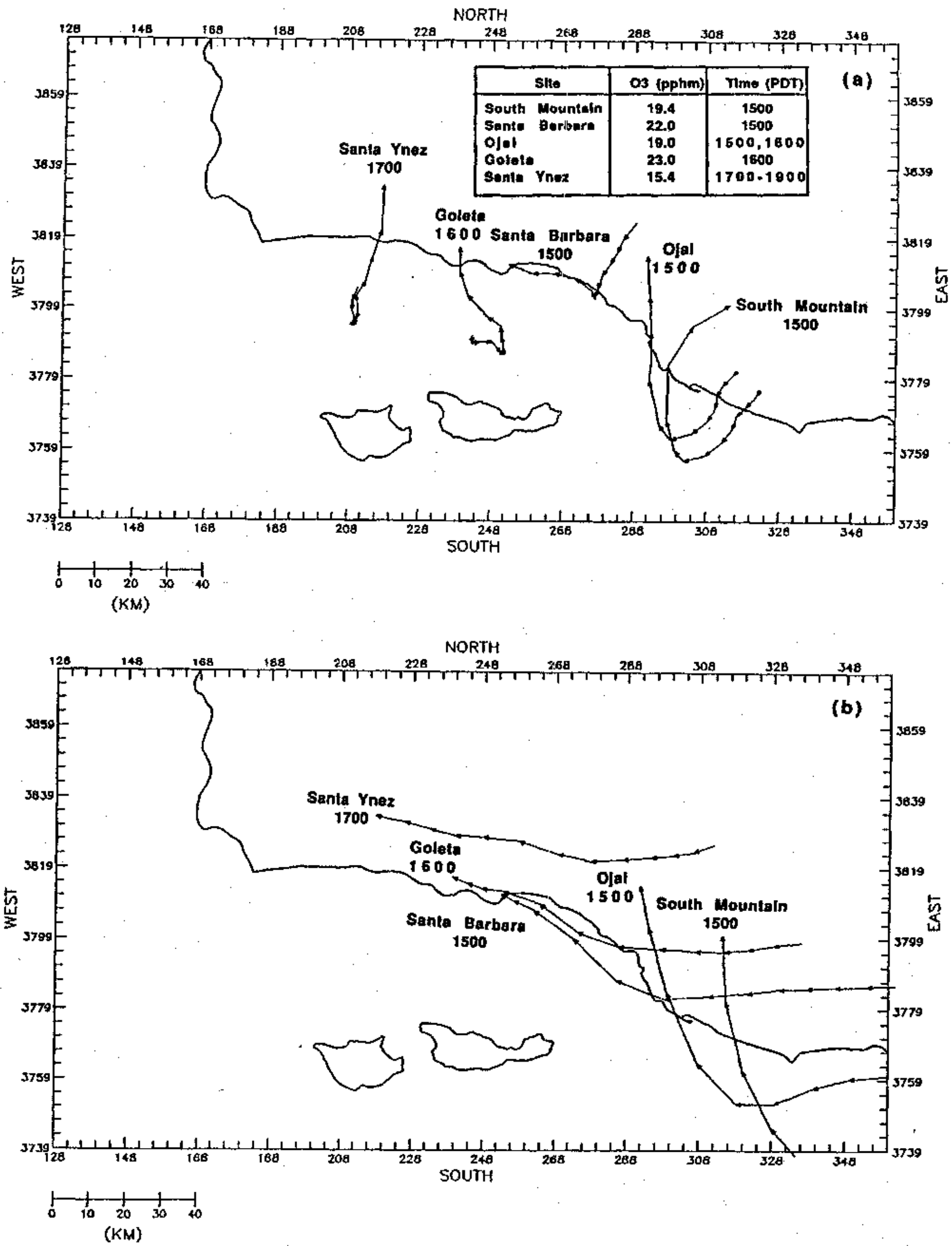


FIG. 13. As in Fig. 4, but for 25 September 1985.



Site	O3 (pphm)	Time (PDT)
South Mountain	19.4	1500
Santa Barbara	22.0	1500
Ojai	19.0	1500,1600
Goleta	23.0	1600
Santa Ynez	15.4	1700-1900

FIG. 14. As in Fig. 7, but for 24 September 1985.

low pressure system moved northwestward and high pressure over the western United States weakened.

2) Mesoscale airflow patterns

Diagnostic analyses of the airflow patterns for 2–4 October at the surface and 300 m AGL are presented in Figs. 15–18.

Mesoscale eddy development over the western channel is illustrated by the 0300 PDT 2 October surface analysis (Fig. 15). This eddy appears to have resulted from northeasterly flow near Point Conception, the persistent northwesterly flow over San Miguel Island, and southerly flow to the north of Santa Rosa Island. The variability of the observations indicate that this eddy is short lived. The remainder of the surface analysis is characterized by northeasterly flow inland, primarily easterly flow over the eastern channel, and offshore-directed flow along the coast. The morning airflow pattern at 300 m consisted of northerly flow along the eastern and western boundaries, northeasterly winds over much of Santa Barbara County, and southeasterly flow over the channel.

The sea breeze developed on this day by 1200 PDT at the surface and reached its maximum inland extent by 1500 PDT (Fig. 16a). The sea breeze mixed upward to 300 m AGL by 1500 PDT (Fig. 16b). The retreat of the sea breeze occurred early on 2 October; by 1800 PDT winds along the coast were very light and by 2100 PDT winds were directed offshore.

On the morning of 3 October, surface winds in the southwestern portion of the domain were very weak. A weak cyclonic eddy was positioned to the west of Point Arguello and another is suggested to the north of Santa Rosa Island. At 300 m the wind gradually veered to the east during the night and by 0300 PDT winds at this level were easterly across the entire analysis domain. The westward extent of the easterly flow is significantly greater than on the other SCCCAMP analysis days.

A low pressure system positioned off the coast of Baja California may account for the emergence of southerly flow on 3 and 4 October. At 1100 PDT on 3 October surface winds were quite variable but primarily southerly. By 1500 PDT (Fig. 17a) southerly flow had penetrated well inland, but spatial variability in the observed wind directions create an unusual pattern of convergence and divergence in the analysis of winds over the channel. The surface winds shifted to the southwest and a more typical sea-breeze regime dominated between 1800 and 2200 PDT. Easterly flow over the channel at the 300-m level became southerly

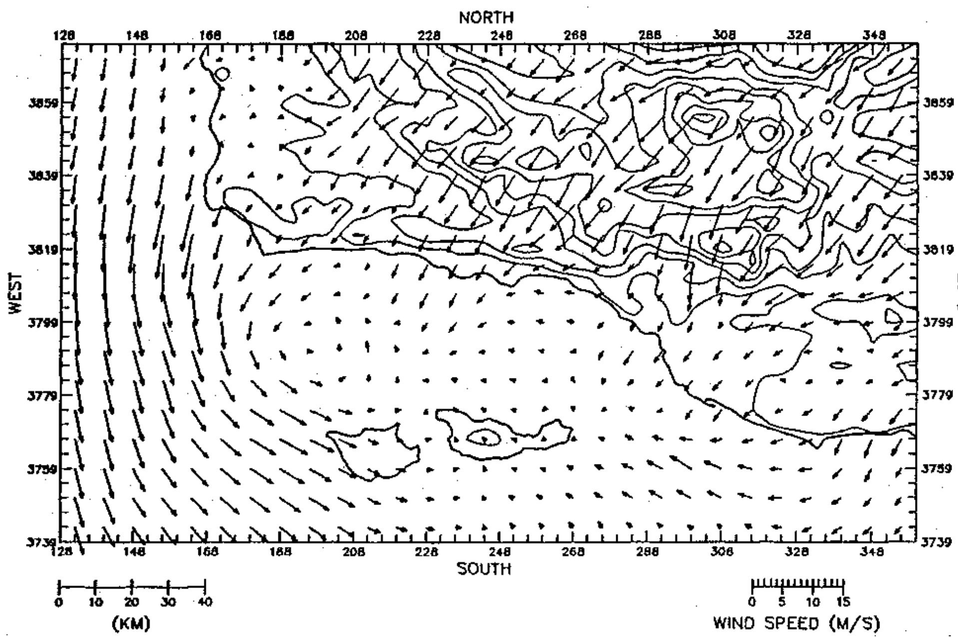


FIG. 15. Diagnostic wind field for 0300 PDT 2 October 1985 at 10 m AGL.

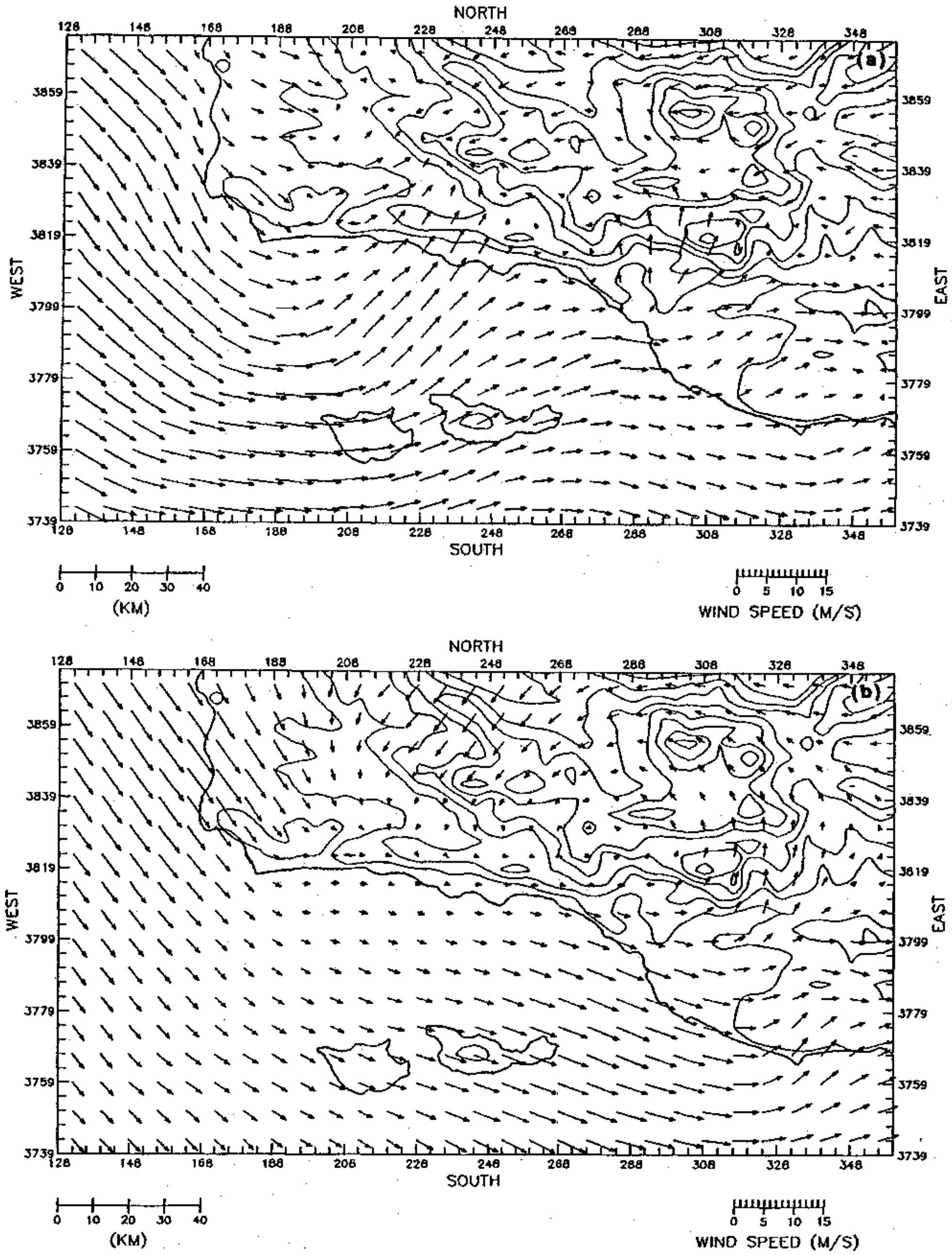


FIG. 16. As in Fig. 4, but for 2 October 1985.

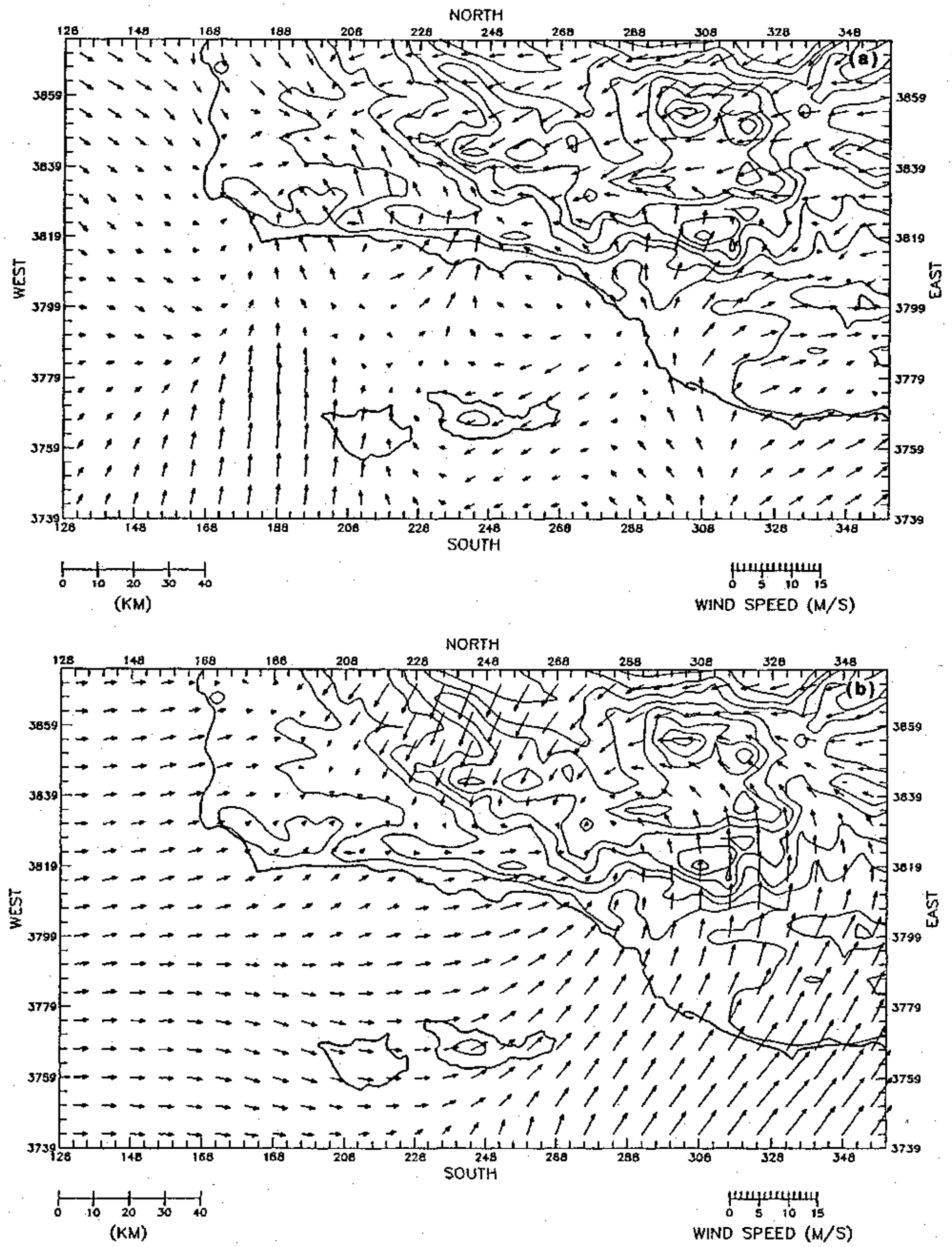


FIG. 17. As in Fig. 4, but for 3 October 1985.

by 1200 PDT and southwesterly by 1500 PDT (Fig. 17b). Winds at this level continued to veer until approximately 1800 PDT.

Airflow patterns on 4 October were similar to those on 3 October. The morning surface analyses suggest a combination of easterly flow and drainage flow over the channel. Southwesterly flow persisted only in the southwestern corner of the analysis domain. The 300-m AGL airflow was undergoing a transition from west to southeast, and the morning airflow was light and variable.

Surface winds over the channel developed a southerly component by 1100 PDT and continued to veer until 1500 PDT (Fig. 18a). Inland penetration of the onshore flow is indicated along the Santa Barbara coast and into Ventura County. Winds in the western part of the domain remained light. The flow over the channel at 300 m AGL (Fig. 18b) continued to veer becoming southerly at 1200 and westerly by 1800 PDT.

3) Ozone air-quality summary

Ozone levels gradually increased between 2 and 3 October. The highest concentrations were observed along the coast and at offshore sites, peaking on 3 October with maximum concentrations of 20 pphm at San Miguel Island, platform Gina, and Anacapa Island. Concentrations gradually decreased on 4 October.

4) Transport patterns

Backward particle paths for 3 October were calculated for Point Dume, platform Gina, Ellwood, Government Point, and San Miguel Island. Peak ozone concentrations occurred at Point Dume at 1400, platform Gina at 1600, San Miguel Island at 1700, and at Ellwood and Government Point at 1800 PDT.

In the eastern part of the domain (Point Dume and platform Gina) the surface-layer particle paths (Fig. 19a) illustrate the effects of offshore flow during the morning hours followed by southerly flow during the afternoon. Particles arriving at Ellwood and Government Point were positioned over the channel 12 h earlier and were advected westward, northwestward, and finally northeastward to the coast. At San Miguel Island, transport from south of the analysis domain is indicated.

Recirculation of pollutants over the channel (with net westward transport) is suggested by the 300-m AGL particle paths arriving at Ellwood, Government Point, and San Miguel Island in the late afternoon of 3 October (Fig. 19b). Possible transport from the south is indicated at platform Gina and Point Dume. Aircraft observations on the afternoon of 3 October detected a shallow polluted air mass over the channel. The particle paths indicate that sources both within and outside of the SCCAB may have contributed to this polluted air mass, which later affected coastal and offshore sites.

5. Summary

An analysis of the mesoscale airflow patterns in the south-central coast air basin (SCCAB) was performed using data collected during the 1985 South-Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP). A large number of surface and upper-air monitoring sites were operated during the SCCCAMP and were primarily located within the coastal and offshore areas. The wind data were analyzed using a diagnostic wind model.

On most of the SCCCAMP intensive measurement days, a regionwide sea breeze develops that is channeled in a coast-parallel (generally west–east) direction by the coastal terrain. The extent of inland penetration of the sea breeze varies from day to day but usually encompasses the Oxnard plain and the Vandenberg area where coastal terrain obstacles are small. The sea-breeze layer can reach depths of 600 to 1000 m. On a number of the intensive measurement days, the development of the sea breeze is retarded or prevented by strong easterly synoptic forcing. A persistent feature of the afternoon wind field is the Gaviota eddy, a circulation that is formed by the persistent northwesterly flow around Point Arguello and upslope flow that develops along the Santa Barbara coast.

Nighttime airflow over the Santa Barbara Channel is generally characterized by propagation of easterly flow westward from the Point Dume area. This flow is opposed by persistent northwesterly flow at the western end of the channel. These opposing flows may contribute to the development of a midchannel eddy (Smith et al. 1983). Mechanisms that may be responsible for the development of this feature are discussed by Kessler and Douglas (1991), Mass and Albright (1989), and Wakimoto (1987). The nighttime airflow is also characterized by the development of offshore-directed downslope and drainage flows along the coast.

The complex mesoscale airflow patterns govern the transport of ozone and ozone precursor pollutants within the SCCAB and through its boundaries. Previous studies have indicated (see Hanna et al. 1991) that both recirculation of pollutants (by the diurnal land-breeze/sea-breeze cycle or eddies such as the midchannel eddy) and transport of pollutants (both at the surface and aloft) into the SCCAB from the SOCAB may contribute to high ozone concentrations in the region. Both mechanisms enhance the possibility that local emissions will produce exceedances of the NAAQS for ozone in the SCCAB. Interbasin transport pathways include 1) westward transport into Ventura County from the San Fernando Valley, 2) transport from the southeast through the inland valleys and along the coast, and 3) overwater transport westward from Los Angeles and then northward into the SCCAB (Hanna et al. 1991).

Backward particle paths indicate that both intrabasin and interbasin transport contributed to high ozone

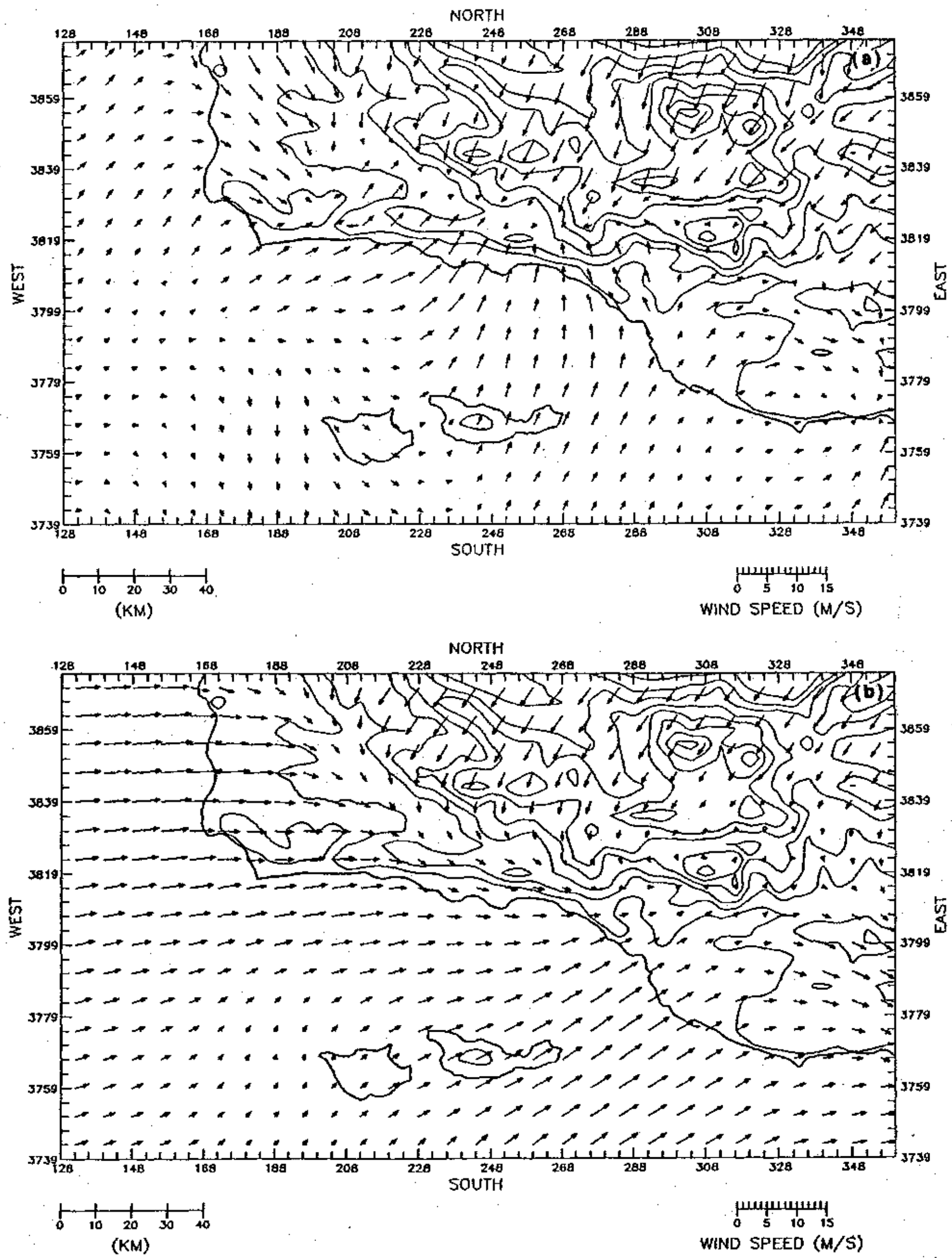


FIG. 18. As in Fig. 4, but for 4 October 1985.

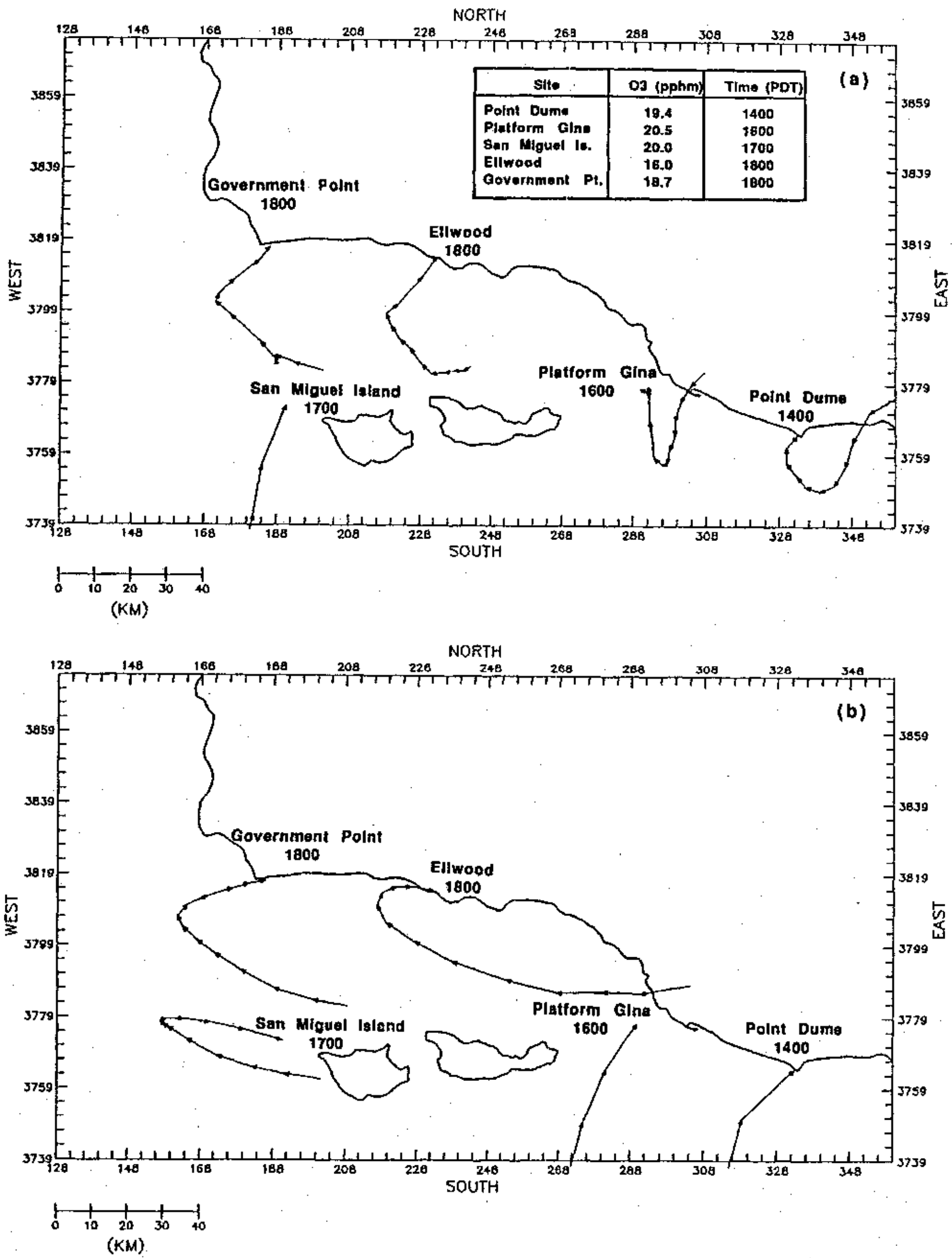


FIG. 19. As in Fig. 7, but for 3 October 1985.

concentrations within the SCCAB on the intensive study days. The surface-layer particle paths for 13 September indicate possible recirculation of pollutants by the land-breeze/sea-breeze cycle while the 300-m AGL particle paths indicate overwater transport from the southeast. On 24 September, the surface-layer particle paths indicate possible recirculation of pollutants and contribution from offshore sources, while the upper-level particle paths indicate transport westward from the San Fernando Valley into Ventura and Santa Barbara counties and overwater transport from Los Angeles into Ventura County. The surface-layer particle paths for 3 October indicate possible recirculation as well as transport from the south, while at 300 m AGL transport from the south (Los Angeles) is indicated in the eastern part of the domain and westward transport while some recirculation is indicated in the western part of the domain. In contrast, particle paths for 21 September (a nonexceedance day) indicate transport of clean air into the SCCAB from the north and from over the ocean and the channel.

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SCOS97-NARSTO
1997 SOUTHERN CALIFORNIA OZONE STUDY AND AEROSOL STUDY

VOLUME III: SUMMARY OF FIELD STUDY

FINAL REPORT
CONTRACT NO. 93-326

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SCOS97-NARSTO
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Mr. Roger Helvy	Shipping Traffic	U.S. Navy	U.S. Navy ($100K)
Dr. Debbie Niemeier	Truck Activity	UC Davis	NREL ($185K)
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Dr. Fred Rogers	Flow Audits	Desert Research Inst	EPRI ($20K)
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1.0 INTRODUCTION AND BACKGROUND

This document provides a summary of field operations during the 1997 Southern California Ozone Study conducted in coordination with the North American Research Strategy for Tropospheric Ozone partnership (SCOS97-NARSTO). To assemble a synopsis of the field measurement program, policy and technical needs that brought stakeholders to participate in the SCOS97-NARSTO are recalled. Milestones for planning of, managing operations of, and analyzing data from SCOS97-NARSTO are provided to show how these needs have been translated and processed into the elements of the study. Field components are presented to briefly describe how the study elements operated and fit together. The SCOS97-NARSTO Technical Committee and working groups are noted for funding of aerometric field measurement program and for managing the study. An inventory of expected reports from SCOS97-NARSTO participants is also provided as a directory of resources for data analysis and for air quality simulation. It is anticipated that these analyses and simulations would produce data useful to developing better compliance strategy for attainment of ozone and aerosol standards in southern California.

To put the field operations summary into the proper context, the topography and the climatology of southern California is discussed in broad terms. To address ozone and aerosol formation and transport within this complex topography and meteorology, elements of operational intensive periods (IOP's) are defined. Forecasting and deployment decisions for each IOP are described. Summaries of overall observations for each episode day are detailed to characterize these IOP's. It is important to note that the forecasting and the field operations programs were successful in capturing data for the episodes most likely to meet the needs of regional air quality simulation.

Data analysts and air quality modelers would use field measurements to characterize and to simulate the atmospheric chemistry of southern California. Therefore, they have a critical need for detailed descriptions of field measurements during SCOS97-NARSTO. During SCOS97-NARSTO, contractors operated supplemental upper-air meteorological and air quality platforms and ground-level air quality and meteorological stations. Regional air quality districts operated existing surface air quality and meteorological stations and conducted additional measurements at these facilities. Parameters measured at each supplemental site are provided to describe spatial and temporal characteristics of southern California's atmospheric chemistry. Parameters measured at each existing site are available from the United States Environmental Protection Agency's Aerometric Information Retrieval System (AIRS) and appendices A and B Volume I of this document. A SCOS97-NARSTO Atlas with descriptions, photographs, and maps of supplemental study sites is provided on a CD-ROM upon request from the Research Division of the California Air Resources Board (ARB). All supplemental and many existing sites were successfully characterized during SCOS97-NARSTO.

1.1 Background and Issues

The 1990 Clean Air Act (CAA) amendments intended to overhaul the planning provisions for those areas not currently meeting the National Ambient Air Quality Standard (NAAQS). The NAAQS for ozone is exceeded when the daily maximum hourly average concentration exceeds 0.12 ppm more than once per year on average during a three-year period. The California State standard is more stringent: no hourly average ozone concentration is to exceed 0.09 ppm. The CAA identifies specific emission reduction goals, requires both a demonstration of reasonable further progress and attainment, and incorporates more stringent sanctions for failure to attain the ozone NAAQS or to meet interim milestones.

According to the 1990 CAA's classification structure for ozone nonattainment areas, the San Diego area is classified as serious, the Ventura and Southeast Desert areas are classified as severe, and the SoCAB is the only area in the country that is classified as extreme. Serious areas must attain the NAAQS by the end of 1999, severe areas by 2005 or 2007 (depending on their peak ozone concentrations), and extreme areas by 2010. The CAA prescribes minimum control measures for each ozone nonattainment area with more stringent controls required for greater degrees of nonattainment.

Emission reduction plans for ozone precursors in serious, severe, and extreme nonattainment areas are submitted to the U.S. EPA as a revision to the California State Implementation Plan (SIP). Each ozone plan contains a current emissions inventory, plans for enhanced monitoring of ozone and ozone precursors, and estimation of future ozone concentrations based on photochemical modeling. Each plan shows a 9 percent reduction in emissions of reactive organic gases (ROG) between 1996 and 1999, and 3 percent reductions per year thereafter, quantified at three year intervals to the attainment date.

The California Clean Air Act of 1988 requires the California Air Resources Board (ARB) to assess the relative contributions of upwind pollutants to violations of the state ozone standard in downwind areas. Previous studies in California have demonstrated pollutant transport between air basins on specific days, but these studies have not quantified the contribution of transported pollutants to ozone violations in downwind areas. Current air quality simulation approaches have several shortcomings in their representation of the physical and chemical processes involved in ozone formation due to the lack of field measurements to evaluate and refine their capabilities (NRC, 1991). In addition, the field measurements used for input to these models and to evaluate their validity do not adequately represent current emission rates, chemical composition, and air quality. The SCAQS was conducted over a decade ago and the South Central Coast Air Basin (SCCAB) has not been extensively studied since the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP) in 1984 and 1985. Since the SCAQS, there have been measurable changes in the air quality of the SoCAB based on analyses of the routinely available monitoring data (Fujita, 1992; Davidson, 1993). The SCOS97-NARSTO is intended to provide another milestone in the understanding of relationships between emissions, transport, and ozone standard exceedances, as well as to facilitate planning for further emission reductions needed to attain the NAAQS.

1.2 Study Goals and Technical Objectives

The goals of the study, recalled from Volume I of this document, are to :

1. Update and improve the existing aerometric and emission databases and model applications for representing urban-scale ozone episodes in southern California

2. Quantify the contributions of ozone generated from emissions in one southern California air basin to federal and state ozone standard exceedances in neighboring air basins. Apply modeling and data analysis methods to design regional ozone attainment strategies.

These goals are to be met through a process which includes analysis of existing data; execution of a large-scale field study to acquire a comprehensive database to support modeling and analysis; analysis of the data collected during the field study; and the development, evaluation, and application of an air quality simulation model for southern California.

Specific technical objectives of SCOS97 are as follows:

1. Obtain a documented data set of specified precision, accuracy, and validity that supports modeling and data analysis efforts.

2. Document the frequency, intensity, and character of high ozone concentrations and its VOC and NO_X precursors within and between neighboring southern California air basins, and determine how these have changed over the past decade.

3. Identify and describe transport pathways between neighboring air basins, and estimate the fluxes of ozone and precursors transported at ground level and aloft under meteorological conditions associated with high ozone concentrations.

4. Quantify the uncertainty of emissions rates, chemical compositions, locations, and timing of ozone precursors that are estimated by emission models.

5. Quantify the uncertainty of meteorological models in simulating transport and mixing of precursors and end-products within and between air basins.

6. Quantify the uncertainty of air quality models in simulating atmospheric transformation and deposition.

7. Provide the meteorological and air quality measurements needed to estimate, with stated uncertainty intervals, the contributions from background, regional mixing and transport, and local emitters to ozone concentrations that exceed standards in each of the air basins.

8. Provide the meteorological and air quality measurements needed to estimate the effects of different emission reduction strategies on ozone concentrations within and

beyond each air basin, and identify those that cause the greatest reduction in population exposure for the least cost.

1.3 Elements of SCOS97-NARSTO

To understand how elements of the study formed a cohesive structure, it is necessary to describe the SCOS97-NARSTO's chronology. The SCOS97-NARSTO Technical Committee (TC), formed early in this chronology, has planned, has directed, has funded, and has managed the study. Working Groups formed from the Technical Committee include the Meteorology, the Air Quality, and the Emission Inventory who, under the guidance of the TC, managed aspects of the study in their respective areas of interest and responsibility. The WGs have been instrumental in preparing and operating the SCOS97-NARSTO. A compressed and concise chronology is provided in Table 1.

In 1993, several air quality management districts in southern California proposed to sponsor the SCOS97 field study to address interbasin transport. In July 1994, the South Coast Air Quality Management District (SCAQMD) hosted an initial planning meeting. The meeting was attended by other districts (Mojave Desert, Santa Barbara County, San Diego, and Ventura County), EPA-Region IX, utilities (Pacific Gas & Electric and Southern California Gas Company), oil companies (Atlantic Richfield Company, Chevron, Texaco and Unocal), industrial research consortiums (Coordinating Research Council and Electric Power Research Institute), and representatives of academia. The TC and WGs were formed to define goals and technical objectives for the proposed study and to provide coordination among sponsoring organizations. Memberships of the working groups are listed in Appendix C of Volume I of this document. A conceptual plan was completed by WGs and approved by the TC in November, 1995. This conceptual plan proposed the study goals and deliverables, the technical objectives, measurement requirements, data analysis activities, and modeling approaches. It is important to note that the planning process began at least two years before the field program, and there was at least one year time to incorporate of the results of pilot studies into the full program plan.

The SCOS97 conceptual plan (ARB, 1995a) provided the basis for the June 1996 draft of the field study plan (Fujita et al., 1996). The draft field study plan matched the SCOS97 goals and objectives with the resources available to do the job, and specified the details of the field study plan that would allow the conceptual plan to be executed. This version of the field study and quality assurance plan reflects the final stages of the planning process for the SCOS97-NARSTO Field Study. The overall design process was iterative and the final plan incorporated input from sponsors, other stakeholders, knowledgeable peer reviewers, and users of the data.

1.0 In further preparation for SCOS97-NARSTO, sponsors executed pilot studies such as the Barstow Halocarbon Study by the Desert Research Institute (DRI). This study in 1994, 1995, and 1996 investigated patterns of air pollution transport between the South Coast air basin and the Mojave and the Saltan Sea air basins. The 1995 Air Pollution Transport Corridors study further investigated the three dimensional nature of this inter-basin transport by employing additional supplemental ozone and meteorological sites and by using an instrumented airplane and a scanning ozone light detection and ranging (lidar) instrument. This study marked the first deployment of a scanning ozone lidar in California. Both these pilot studies contributed to our knowledge of the most important sites and times to characterize and to monitor these interbasin air pollution transport couples and the siting of many SCOS97-NARSTO supplemental ozone sites. The Upper-Air Ozone Measurement Intercomparison Study at Walnut Grove and at Sandia National Laboratory allowed comparison of data from and evaluation of an ozonesonde, an instrumented aircraft, and an ozone lidar (Sandia) that was originally designed for monitoring atmospheric water content. A scanning ozone lidar, a lidar operating in generally the same manner as the Sandia lidar [operated for only two weeks], ozonesondes, and instrumented airplanes provided the primary air quality data aloft during SCOS97-NARSTO intensive operational periods.

In a preliminary effort, the emission inventory WG reviewed and corrected a Systems Application International (SAI) produced 1990 base emission inventory sponsored by ARB. This base inventory would then be used to develop a gridded 1996 base emission inventory which would then be grown into a 1997 gridded emission inventory. This emission inventory system would then be ready to integrate the day specific emission inventory data collected during SCOS97-NARSTO. To investigate ship borne emissions, the United States Navy planned and executed a pilot study on ship traffic into and out of the southern California bight. Members of the emission inventory WG have asked major sources in their domains for day-specific information and nearly sixty percent have already provided such data. Under contract to ARB, University of California Davis collected light-duty vehicle and heavy-duty truck traffic counts as inputs for traffic models. Depending on the release of growth factors and other related information from the Southern California Association of Governments, it is estimated that the emission inventory process would meet the air quality modeling chronology.

All three WGs put significant emphasis in selecting their QA programs and the TC selected the DRI as the overall SCOS97-NARSTO QA manager. The speciated hydrocarbon and carbonyl sampling QA relied on round-robin interlaboratory and intermethod comparisons. Whenever possible different measurement methods were collocated to permit comparisons for estimating accuracy and validity of the data. These measurements included ozone from lidar and from instrumented airplanes, PAN, NO_y, aerosols, radiation, and upper air meteorology. The meteorology WG planned and executed an extensive program of system and performance audits for upper air meteorology, which will be discussed in detail later. For nitric acid, the tunable diode laser spectroscopic was used as a "reference" method. Data archival has been emphasized as an integral part of the overall study and will be sited at ARB Technical Support Division. Data reporting conventions, site documentation, and units have been established and communicated to the study participants. Extensive data management and "Level 2" data validation for the upper-air meteorology, air quality aloft, speciated hydrocarbon and carbonyl, and NOY data has been planned.

On May 15, 1997, SCAQMD hosted the Measurement Coordination Meeting where intensive operational period (IOP) protocols and data exchange agreements were discussed and approved. Program management and quality assurance issues were resolved at this meeting. The SCOS97-NARSTO field operations program began on June 16 and ended on October 15, 1997. Due to the El Niño driven climatology and the introduction of federal and California reformulated gasolines, the conditions for formation of high ozone episodes were less robust than during the 1993 Los Angeles Free Radical Study. Nevertheless, high ozone conditions were observed on July 3 [a non-IOP day due to unusual emission patterns], August 4 to 7, 22 to 23, September 3 to 6, 22 to 23, and 27 to 29, 1997. More detailed description of the IOP days are provided in the section 2.5 of this document.

To prepare for the upcoming State Implementation Plan 2000 for ozone and aerosols, early emphasis will be on airshed modeling of the SCOS97-NARSTO data. SCAQMD has sponsored Sonoma Technology, Inc (STI) to provide guidance, inputs, and data for evaluation of emissions, meteorological, and photochemical models, as part of the air quality management plan process. This project will also validate the SCOS97-NARSTO speciated hydrocarbon and carbonyl data and determine the air quality and meteorological representativeness of the SCOS97 episodes. ARB Research Division would conduct more observation-based analyses of upper-air quality and the NO_Y data. This group would also conduct observation-based and receptor modeling analyses on the data from the Aerosol Study during SCOS97-NARSTO. The summary and preliminary analyses of the SCOS97-NARSTO results will be presented at the 1998 Air and Waste Management Association's 91st Annual Meeting in San Diego, California. A Data Management and Analysis Plan will be prepared and presented to the TC in August of 1998. The University of California Los Angeles will host the SCOS97-NARSTO Data Analysis Symposium in June of 1999. Selected papers from this symposium will be combined in the SCOS97-NARSTO issue of Environmental Science and Technology. The SCOS97-NARSTO data will likely provide the basis for air quality scientific inquiry and air pollution policy in southern California for the next decade.

The SCOS97-NARSTO benefited from a communication system that heavily relied on the world wide web for disseminating IOP decisions, meteorological and air quality forecasts, and during the study even provided upper-air meteorological profiles from selected sites in a timely manner. Traffic count updates and other real-time resources describing conditions in southern California were also available to study participants through the world wide web. A list of selected SCOS97-NARSTO related sites is provided in Table 2 of this document. These sites provide information, reports, and data connected with the SCOS97-NARSTO. For information on SCOS97-NARSTO level II data's future release times and exchange protocol, it is recommended that the ARB Research Division site be monitored.

1.4 Components of the SCOS97-NARSTO Field Study

Since Dr. Haagen Smit explained the basic nature of photochemical smog in 1952, research in the laboratory and the real world has focused on better understanding the nuances of the complex photochemical processes that occur in our atmosphere. But, routine monitoring for many of the "exotic participants" in the photochemical reactions such as peroxy acetyl, proxy propionyl, and other organic nitrates is outside our technical and/or financial resources. Other "exotic participants" such as isoprene, and other biogenic emissions, and product of their atmospheric oxidation by free radicals, until recently, had not been measured in real-time. Even basic building blocks of atmospheric chemistry of ozone and aerosols such as nitrogen dioxide, hydroxyl radical, nitric acid, and ammonia are extremely difficult to measure directly and in real time with sufficient sensitivity, accuracy, and precision. Major field studies are occasionally conducted with components specifically designed to measure these "exotic participants" so that we may learn the details of the atmospheric processes and how we may need to change emissions in the future to attain healthful air for the residents of California.

Ironically, many of these field studies (which take years to plan) unintentionally occurred during years when air pollution levels were lower than normal. No matter the meteorological conditions, the process of improving air quality relies on conducting field studies and incorporation the results into the planning process for controlling emissions. The SCOS97-NARSTO was also "plagued" by good meteorology when the smog season of 1997 (the cleanest season on record) produced only one Stage One ozone episode (1-hour concentration 20 pphm)--in contrast to seven, 14, 23, 24, and 41 during the prior five years. The good dispersion of pollutants during this study (which included the effects from three hurricanes in the study area) is generally credited to the well-publicized El Niño.

The field study portion of SCOS97-NARSTO was designed to maximize the chances of capturing high ozone episodes and to fill in the "holes" in our knowledge uncovered by previous studies.

Five types of ozone episodes in southern California were of interest. The study was successful in capturing all of the episode types except one (Type 5--Offshore Transport to San Diego). This last episode type was partially captured because it did occur two weeks after the study officially ended while certain SCOS97-NARSTO monitoring resources were still operational.

Remote sensing methods were employed to continuously monitor meteorological conditions aloft throughout the study period of June 16 through October 15. Previous studies provided only limited characterization of meteorological conditions aloft (with balloons and aircraft deployed during periods forecast to have high ozone concentrations) and this severely hampered the analyses of data in this area of complex meteorology and topography. In SCOS97-NARSTO, a network of 35 remote sensing systems was established (the densest network of radar wind profilers and sodars ever assembled) to continuously monitor wind and temperature conditions aloft throughout and around the South Coast Air Basin. During periods when high ozone concentrations were forecast, additional measurements on conditions aloft were obtained by means of ozonesonde releases at seven sites, rawinsonde releases at thirteen sites, six aircraft, and two lidars; in all, over 1,000 balloons were released during the study. At over 20 surface monitoring sites and on three aircraft, volatile organic compounds were sampled. These additional measurements provide critical detailed information pertinent to running and validating air quality models.

Because previous modeling efforts underestimated the amount of ozone in the central basin where ozone concentrations tend to be highest, the El Monte Airport, near the center of the basin, was established as the hub site for enhanced monitoring. An ozone lidar and a radar wind profiling system (RWP) were operated nearly continuously during the intensive periods to identify the dynamics of ozone and meteorological conditions with height and time. These data were supplemented by measurements of ozone, oxides of nitrogen, temperature, humidity, and particles on up to nine aircraft spirals during daylight hours.

Previous studies demonstrated the complexity of air circulation over the southern California bight and how important it is to adequately characterize the offshore meteorological conditions and air quality. Air quality and meteorological monitoring offshore were greatly enhanced for the SCOS97-NARSTO which included sites on San Clemente, San Nicolas, Santa Catalina, and Santa Rosa Islands as well as at eight new coastal locations; measurements of conditions aloft were taken at eight of the dozen sites. During intensive operational periods, an instrumented aircraft (making morning and afternoon flights) provided additional, detailed data on conditions in the southern California bight during over-water sampling in an elliptical path encompassing the islands. On occasion, a second aircraft mapped the distribution of ozone concentrations inside the northeast quarter of the ellipse by sampling over the ocean west and southwest of Santa Monica Bay.

An important objective of SCOS97-NARSTO was to understand why ozone levels are improving at a slower rate on weekends than weekdays, the so-called "weekend effect." For the first time, detailed information (over 300 megabytes of data a day) was collected on the operations of cars, trucks, airplanes, ships, and major point sources every day for four months. This data will be analyzed to determine the differences in pollutant emissions on weekdays and weekends. Also, day-specific biogenic hydrocarbon emissions inventories are being assembled for comparison with the anthropogenic emissions.

An aerosol component of the study collected detailed data on the size distribution of particles at ground level and aloft. Real time measurements were also made of particles at some ground level sites. Size and composition information on over two million individual particles were collected during at least ten different types of fine particle episodes. Despite a shoestring budget, a wide variety of simple and sophisticated solar radiation instruments were brought to the study for evaluation of the sensitivity of ozone formation to both the radiation absorbing and scattering properties of particles. During another component of the study, releases of up to five different tracers were made to simulate emissions from shipping channels. This information will be used to compare how ship emissions from the current and proposed shipping lanes might impact air quality when they come on-shore.

Despite the cleanest air quality on record for the study area, the team of forecasters successfully predicted the days with the second and third highest concentrations (the day with the highest concentration of the year was not of interest because it occurred on July 3 after several days of forest fires and when traffic patterns were likely atypical due to the holiday weekend).

Although the monitoring phase of SCOS97-NARSTO is over, much work remains as the study participants attempt to fully utilize the data collected and address the informational needs of the study sponsors. This study will provide the first detailed analyses of the causes contributing to violations of the new national 8-hour ozone and 24-hour PM2.5 standards. The data collected will be used in modeling and data analyses that will provide the most definitive answers yet to solving the persistent air quality problems in a complex region. The cooperation of the study sponsors (U.S. EPA, local air pollution control districts, U.S. Marine Corps, U.S. Navy, National Renewable Energy Laboratory, Coordinating Research Council, EPRI, Southern California Edison, and ARB) in integrating and "piggybacking" projects made it possible to leverage the available funds for maximum scientific benefit.

1.5 Sponsors and Management

SCOS97-NARSTO has been a large undertaking involving many contractors, sponsoring organizations and governmental agencies. In a cooperative study such as this, no one person can have direct management authority over all phases of the study. Since direct fiscal responsibility will remain with the California Air Resources Board (ARB), South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD), Ventura County Air Pollution Control District (VCAPCD), Mojave Desert Air Quality Management District (MDAQMD), United States Navy, Coordinating Research Council (CRC), the management structure for SCOS97-NARSTO reflects this consortium of sponsors. The setting for the development and progress of this consortium has been the SCOS97-NARSTO Technical Committee. A list of study personnel and supporting organizations is provided in the preamble to this volume. Lists of in-kind support are provided in specific measurement categories in the Volume I of this document.

The Technical Committee (TC) has set the goals of the study and has made decisions regarding general study objectives, funding, and selection of contractors. The TC is made up of technical staff members from ARB (Research and Technical Support Divisions), SCAQMD, SDAPCD, VCAPCD, Santa Barbara APCD, MDAQMD, EPA-Region IX, United States Marines, and United States Navy. The TC has directed the planning efforts and has coordinated the technical activities of the contractors to ensure that the measurement, emission, modeling, and analysis activities are coordinated with each other and focused on the study objectives. A list of the TC members is provided in Appendix C of Volume I, The Operational Program Plan, of this document.

The Meteorology Working Group was primarily responsible for the largest and the most dense network of upper-air meteorological measurements ever assembled in southern California. This network included 28 Radar Wind Profiler and Radio Acoustic Sounding Systems (RWP-RASS), 7 Sound Detection and Ranging Systems (sodars), rawinsonde launches from 13 launch sites, and meteorological data associated with ozonesondes from 7 launch sites. The rawinsonde launches were restricted to 4 times daily during intensive operational periods. The MWG was also primarily responsible for the success of system and performance audits conducted during the study to assure the highest quality meteorological data was collected during SCOS97-NARSTO. MWG leaders have come from ARB (Bruce Jackson – co-chair and Steve Gouze), from SCAQMD (Joe Cassmassi – co-Chair and Kevin Durkee), from SDAPCD (Bill Brick and Virginia Bigler-Engler), from VCAPCD (Kent Field), and from U.S. Navy (Roger Helvy and Jay Rosenthal).

The Air Quality Working Group is primarily responsible for developing, operating, and managing the first total reactive nitrogen species (NO_Y) network in southern California and the ozone sites supplemental to the Routine Network. Supplemental ozone sites are sites operated specially for SCOS97-NARSTO or are sites whose data have not been routinely submitted to AIRS. State and Local and National Air Monitoring Stations (SLAMS and NAMS) data are routinely submitted to AIRS. This, Routine Network, collects aerometric data including ambient concentrations of gases such as ozone, oxides of nitrogen, sulfur dioxide, carbon monoxide, methane, and ambient meteorological parameters such as temperature, relative humidity, wind parameters, pressure, radiation, and aerosols data such as particulate matter less than 10 micron in aerodynamic size (PM10). During 1998 and later, many sites in this Routine Network will also collect PM less than 2.5 micron in aerodynamic size (PM2.5 or PM Fine) data. The quality of the data and what parameters are collected vary considerably from site to site. This is primarily due to regional district's resources and their ozone and aerosol attainment demonstration status. It is important to understand that to a certain extent the NO_Y, the speciated hydrocarbon and carbonyl (VOC), and the aerosol networks were essentially superimposed on existing Routine Network. The Routine Meteorological Network includes the aerometric stations, as well as those stations operated by the National Weather Service, National Park Service, and fire safety and prevention concerns. Types of SCOS97-NARSTO sites are discussed in detail in section 3.1 of this volume.

The VOC network improved the spatial and temporal extent and data quality assurance of the Photochemical Assessment Monitoring Stations (PAMS) at 20 stations in the SCOS97-NARSTO domain. The NO_Y network operated at 14 sites, five were new sites where ozone and meteorological parameters were also measured. There were 31 supplemental ozone sites during SCOS97-NARSTO. It is important to note that there were supplemental stations that collected ozone, aerosol, and NO_Y data simultaneously. It is also important to note that some supplemental stations, those in the Children's Health Study Network, are operated year-around and on a semi-permanent basis.

The study's Field Program Management Committee (FPMC) provided the day-to-day technical management during the field study. The FPMC made decisions regarding intensive operation periods, and contingency funding. This committee included a single representative from the ARB Research Division (Bart Croes), ARB Research Division (Don McNerny), SCAQMD (Henry Hogo), SDAPCD (Judy Lake - Chair), VCAPCD (Doug Tubbs), U.S. EPA (Carol Bohnenkamp), U.S. Navy (Jay Rosenthal).

The forecast team developed the Forecast Plan in conjunction with the field manager, reviewed meteorological data, and provided consensus forecasts to the FPMC. The forecast team also documented the daily meteorological conditions during 1997. This team included a single representative from the ARB (Steve Gouze), SCAQMD (Joe Cassmassi – Chair), SDAPCD (Virginia Bigler-Engler), VCAPCD (Kent Field), and U.S. Navy (Jay Rosenthal).

The Field Managers coordinated the activities of the field contractors (in-kind personnel will be under the direction of their management/FPMC members). Jim Pederson (upper-air meteorology), Leon Dolislager (air quality), Dr. Ash Lashgari (surface meteorology, ozone and NOy) and Dr. Randy Pasek (VOC) of the Air Resources Board Research Division were the FMs and the main contact points to relay information on measurement readiness status during and between the intensive operational periods (IOPs). Mr. Bart Croes of the Research Division coordinated their activities and provided day-to-day communication and leadership support.

The Quality Assurance manager has been responsible for developing the QA plan in conjunction with the field managers and field contractors. The QA manager supervised the systems and performance audits and reported their results to the field manager and field contractors. The QA manager has worked with the data manager to develop quality assurance data screening protocols and has managed the data quality assurance efforts. Dr. Eric Fujita of the Desert Research Institute has been the QA manager and has reported to the SCOS97 Technical Committee.

The Data Manager is responsible for developing the data management plan in conjunction with the field managers and field contractors. The data manager works with the field manager, measurement contractors, modelers, and analysts to develop standard data formats for use in the study. The data manager is responsible for obtaining project data and supplemental data, integrating the data into a common database, performing Level 1 screening of the data, providing the data to the QA, analysis, and modeling contractors, and documenting and maintaining the data archive. Mrs. Liz Niccum of the Air Resources Board Technical Support Division has been designated the data manager.

The data management process is the beginning of the analysis and modeling of SCOS97-NARSTO data set. This process would soon lead to the availability of this massive data set to the community of atmospheric scientists.

1.6 Guide to Study Reports

To better understand this data set and to be able to focus the scientific inquiry into diverse aspects of the SCOS97-NARSTO, it is important to note what reports are, and would be, available to guide any search for relevant data. Volume I and III of this document are particularly useful for planning of future studies such as the San Joaquin Valley Study 2000 or other studies with limited focus on aerosols, on nitrogen species measurements, and on radiation issues. Volume II reflects the SCOS97-NARSTO QA approach, which would be useful to understand the outlines of the QA program in each particular area and SCOS97-NARSTO innovations on how specific QA programs would be designed. This volume, IV, serves to high light particulars of SCOS97-NARSTO field operations; this volume is useful to focus on particular IOP's and the measurements of particular relevance during each IOP of interest. Volume V documents actual QA practices to guide the selection of what information are abstracted from the data set.

Other upcoming reports from contractors who participated in the SCOS97-NARSTO field program are listed in Table 3. It is important to note that this list would likely be updated and made part of the SCOS97-NARSTO ARB Research Division internet site.

Table 1
SCOS97-NARSTO CHRONOLOGY

Date	Milestone
September 1993	RSC meeting - Present planning RFP
December 1993	RFP released
February 1994	Responses received
March 1994	RSC Meeting - Planning RFP awarded to DRI
July 1994	Concept Meeting at South Coast AQMD - Formation of TC
January 1995	Feasibility study for a southern California Air Quality Monitoring Study. Report prepared by SAI for CRC
May-October 1995	Pilot studies - Barstow Halocarbon Study, ozone aloft monitoring, and scanning lidar evaluations
November 1995	Conceptual Plan for SCOS97-NARSTO prepared by the TC and WGs
June 1996	Draft SCOS97 Field Study Plan prepared by DRI with input from TC and WGs
August 1996	Preliminary regional meteorological modeling
October 1996	SCOS97 sponsors release RFPs
December 1996 -March 1997	Contracts in place
April 1997	Draft SCOS97-NARSTO Quality Assurance Plan prepared by DRI with input from TC, WGs, and measurement contractors
May 1997	Measurement Coordination Meeting
June 1997	Final SCOS97-NARSTO Field Study and Quality Assurance Plan prepared by DRI with input from TC, WGS, and measurement contractors
June 16, 1997 to October 15, 1997	Conduct SCOS97-NARSTO field study
May 1998	RSC Meeting – Present Operational Plan, Quality Assurance Plan, Aerosol Study Field Plan, Summary of Field Operations, Summary of Quality Assurance
June 1998	Complete assembly and validation of data archive
June 1998	SCOS97-NARSTO symposium I – AWMA 91st Annual Meeting – Review of field study and preliminary interpretation of data
August 1998	TC Meeting – Present Data Management and Analysis Plan
March 1999	Complete data analysis
June 1999	Regional meteorological modeling evaluation and emission inventory due for the SIP process
June 1999	SCOS97-NARSTO symposium II – ES&T Special Issue – Data Analysis
January 2000	Regional air quality model evaluation due for the SIP process
June 2000	Regional control strategy assessment due for the SIP process

Table 2
SCOS97-NARSTO WORLD WIDE WEB SITES

Source	Address
ARB	http://arbis.arb.ca.gov/homepage.htm
ARB	http://www.arb.ca.gov/scos/scos.htm
ARB Monitoring Sites	http://arbis.arb.ca.gov/aqd/ozone/lst1_ste.htm
NOAA	http://www7.etl.noaa.gov/programs/SCOS97/
NOAA	http://www4.etl.noaa.gov/index.html
DRI	http://www.dri.edu/EEEC/Faculty/Fujita.html
CE-CERT	http://cert.ucr.edu/~macm/
CE-CERT	http://www.cert.ucr.edu/ap/air.html
U.S. Navy	http://www.enviro.navy.mil/
U.S. Navy	http://web.nps.navy.mil/~cirpas/past_proj.html
Santa Barbara CAPCD	http://www.silcom.com/~apcd/ota/mayjun97.htm
South Coast AQMD	http://www.aqmd.gov/scos97/
South Coast AQMD	http://www.aqmd.gov/news/smog97_1.html
UCLA	http://www.ph.ucla.edu/ese/w_rsrch.htm
EPA	http://www.epa.gov/region09/air/
EPA	http://www.epa.gov/region09/air/sip/casip3.html
Mojave Desert AQMD	http://www.mdaqmd.ca.gov/
San Diego CAPCD	http://www.sdapcd.co.san-diego.ca.us/scos97.html
U.S. Dept of Energy	http://www.doe.gov/
CRC	http://crcao.com/
Cal Trans	http://www.scubed.com/caltrans/

Cal GAP Project	http://www.biogeog.ucsb.edu/projects/projects.html
NARSTO	http://odysseus.owt.com/Narsto/1998NewsletterWS.pdf
PSU	http://horizons.sb2.pdx.edu/~fage/
CIMIS	http://wwwdpla.water.ca.gov/cimis/cimis/hq/
NWS	http://nimbo.wrh.noaa.gov/wrhq/profile.html
NPS	http://www.aqd.nps.gov/ard/
NPS ARD	http://www.aqd.nps.gov/ard1/
NPS IMPROVE	http://www.aqd.nps.gov/ard1/investhp.html

Table 3
GUIDE TO STUDY REPORTS

Contractor	Number	Expected Date	Sponsor	Title
SJSU- Bob Bornstein Penn State- Nelson Seaman	97-310	July 2000	ARB-RD	*Improvement and Evaluation of the Mesoscale Meteorological Model MM5 for Air Quality Applications in Southern California and the San Joaquin Valley*
UC Berkeley- Rob Harley	96-335	December 99	ARB-RD	*Review and Improvement of Methods for Estimating Rates of Photolysis in Photochemical Models*
UC Riverside- CE-CERT-Dennis Fitz	96-504	September 98	ARB-RD	*Measurement of Nitrogenous Species & Solar Intensity During SCOS97*
NOAA-Yanzeng Zhao	95-337	December 98	ARB-RD	*Measurement of Ozone Concentrations Aloft During the Episodic Monitoring Periods of the SCOS97*
STI-Don Blumenthal	96-309	November 98	ARB-RD	*Investigation of Processes Leading to the Formation of High Ozone Concentrations Aloft in Southern California*
UCD- John Carroll	95-332	September 98	ARB-RD	*Aircraft Measurements in Support of SCOS97*
U.S. Navy, Naval Facilities Engineering Service Center-Norm Helgeson	97-304	October 98	ARB-RD	*Measurements of Ozone and Meteorological Conditions in the Low Atmosphere During SCOS97*
California Institute of Technology-John Seinfeld	96-315	February 99	ARB-RD	*Aircraft Sampling to Determine Atmospheric Concentrations & Size Distributions of PM & Other Pollutants over the SoCAB*
UC Riverside - CE – CERT-Dennis Fitz	96-322	November 98	ARB-RD	*Surface and Upper-Air VOC Sampling and Analysis During SCOS97*
NoAA-Bob Weber	96-323	October 98	ARB-RD	*Management of Data from the Upper-Air Meteorological Network for SCOS97*
AeroVironment- Bob Baxter	96-320	August 98	ARB-RD	*Audit of Radar Wind Profiler Network and Selected Surface Meteorological Sites for the SCOS97*
AeroVironment- Bob Baxter	96-320	August 98	ARB-RD	*Addendum to the final QA report, soundings made by the ARB and the U. S. Navy for QA purposes at 12 radar wind profiler sites will be compared with radar wind profiler soundings*
NOAA-William Neff	95-345	March 99	ARB-RD	*Enhancement of the Existing Radar Wind Profiler Network for SCOS97*
UCLA- Arthur Winer-Proposal .	2354-202	June 2000	ARB-RD	*Development and Validation of Databases for Modeling Biogenic Hydrocarbon Emissions in California's Airsheds*
UCLA- Arthur Winer	95-309	September 98	ARB-RD	*Biogenic Hydrocarbon Inventories for California: Generation of Essential*

				Databases
Radian/STI- George Frederick	96-318	May 99	ARB-RD	*Enhancement of the Existing Radar Wind Profiler Network for SCOS97*
SAI-Julie Fieber	974-734	March 97	ARB-TSD	*Preparation of a Draft 1990 Gridded Emission Inventory for Southern California*
RFP	97-715	June 2000	ARB-TSD	*Develop SCOS-97 NARSTO Gridded Emission Inventories*
AeroVironment- David Pankratz	96-719	September 98	ARB-TSD	*Supplemental Monitoring for Recirculation Patterns in the SoCAB*
UC Riverside - CE – CERT- Dennis Fitz	95-723	September 98	ARB-TSD	*Performing Ozonesonde Measurements for the SCOS97*
STI-Paul Roberts	-	July 99	SCAQMD	*PAMS and SCOS97 Data Analysis Project*

2.0 SYNOPSIS OF THE SCOS97-NARSTO FIELD MEASUREMENT PROGRAM

2.1 Study Scope

There are seven air basins in the SCOS97 domain (shown in Figure 2-1): the San Joaquin Valley (southern part of Kern County only), South Central Coast (Ventura County, Santa Barbara County and southern portion of San Luis Obispo County), South Coast, San Diego, and Mojave Desert and Southeast Desert Air Basins (abbreviated SJVAB, SCCAB, SoCAB, SDAB, and SEDAB, respectively). The study area includes about 53,000 square miles in the southern portion of the State, with a population of more than 18 million. Seven percent of the entire U.S. population, and more than half the population of California, live in the South Coast Air Basin alone. This region of California is an area of complex terrain (see Figure 2-2) — bounded by the Pacific Ocean to the west; to the north by narrow coastal mountains and valleys, the San Joaquin Valley, and the Sierra Nevada Mountains; and to the south and east by the California state border. Although the air basin boundaries were established with topographical features in mind, winds can and do transport pollutants from one basin to another.

The study dates were June 16 to October 15, 1997. The measurements to be made each day throughout the four-month study period included:

- Activity data for freeway traffic, major point sources, commercial and naval ships, commercial aircraft, and wildfires;
- Vertical profiles of winds and temperature from radar wind profilers with radio acoustic sounding systems (RWP/RASS) or SODARs at 32 sites;
- Vertical profiles of winds, temperature, and humidity from rawinsondes 1 or 2 times per day at 4 to 8 sites (depending on the day of the week);
- Speciated volatile organic compound (VOC) sampling every third day (2, 4, or 8 times a day) at 11 sites, and daily analysis 8 times a day at Burbank and Pico Rivera;
- Total reactive nitrogen (NO_y) at 14 sites and nitric acid (by difference) at 10 of those sites;
- Ozone and meteorology at 31 supplemental sites;
- Ozone, total nitrogen oxides (NO_X), and meteorology at 96 existing Air District sites;
- Surface meteorology at over 200 existing sites;
- Specialty radiation at Mt. Wilson and UC Riverside; and
- Total solar radiation at 78 existing sites.

During the month of September, additional continuous measurements include:

- Vertical profiles of ozone, aerosol extinction, temperature, and humidity from a lidar at Hesperia;
- Speciated VOC analysis 24 times a day at Azusa; and
- Hydroxyl and hydroperoxyl radicals, speciated VOC analysis, ozone, NO_X, CO, aerosol size, and ultraviolet radiation at UC Riverside.

Measurements to be made only during IOPs include:

- Vertical profiles of winds, temperature, and humidity from rawinsondes 4 times per day at 11 sites;
- Vertical profiles of ozone and aerosol extinction from a lidar at El Monte Airport;

- Air quality and meteorology aloft from 4 full-time and 2 part-time aircraft;
- Vertical profiles of ozone, temperature, and humidity from ozonesondes 4 times per day at 7 sites;
- Speciated VOC sampling at 25 sites, and aboard 4 aircraft;
- Halocarbons at 6 sites;
- Biogenic hydrocarbon and methylnitronapthalene sampling at 3 sites;
- Specialty nitrogen and VOC at Azusa;
- Peroxyacetyl nitrate (PAN) at 4 sites with peroxypropyl nitrate (PPN) at 2 of the sites; and
- Real-time single particle size and chemical composition at 3 sites.

Three additional studies are being conducted in coordination with the main SCOS97-NARSTO study described above:

- Aerosol program to be conducted between August 16 and September 14. It includes surface street traffic counts at 12 sites, state-of-the-art particle measurements at 3 sites, and a specially instrumented airplane along two separate air trajectories in the SoCAB (see Appendix A for a more complete description).

- Additional specialty radiation measurements at Mt. Wilson and UC Riverside during June 29 to July 5 and the first IOP between September 2 and 12.

- Tracer study with off-shore releases of 5 different perfluorocarbons during four 2-day periods between August 15 and October 15.

2.2 Study Area Climatology

Given the primary emissions within the complex terrain of southern California, it is the climate of southern California that fosters generation of ozone, a secondary pollutant. High ozone concentrations most frequently occur during the "ozone season," spanning late spring, summer, and early fall when sunlight is most abundant. Meteorology is the dominant factor controlling the change in ozone air quality from one day to the next. Synoptic and mesoscale meteorological features govern the transport of emissions between sources and receptors, affecting the dilution and dispersion of pollutants during transport and the time available during which pollutants can react with one another to form ozone. These features are important to transport studies and modeling efforts owing to their influence on reactive components and ozone formation and deposition..

Southern California is in the semi-permanent high pressure zone of the eastern Pacific. During summer, average temperatures are ~25 °C, with maximum daily readings often exceeding 35 °C. Precipitation events are rare. Frequent and persistent temperature inversions are caused by subsidence of descending air which warms when it is compressed over cool, moist marine air. These inversions often occur during periods of maximum solar radiation which create daytime mixed layers of ~1,000 m thickness, though the top of this layer can be lower during extreme ozone episodes (Blumenthal *et al.*, 1978). Relative humidity depends on the origin of the air mass, proximity to the coast, altitude, and the time of day, and can exceed 50 percent during daytime throughout the SoCAB with the intrusion of a deep marine layer. Relative humidity is higher near the coast than farther inland (Smith *et al.*, 1984a).

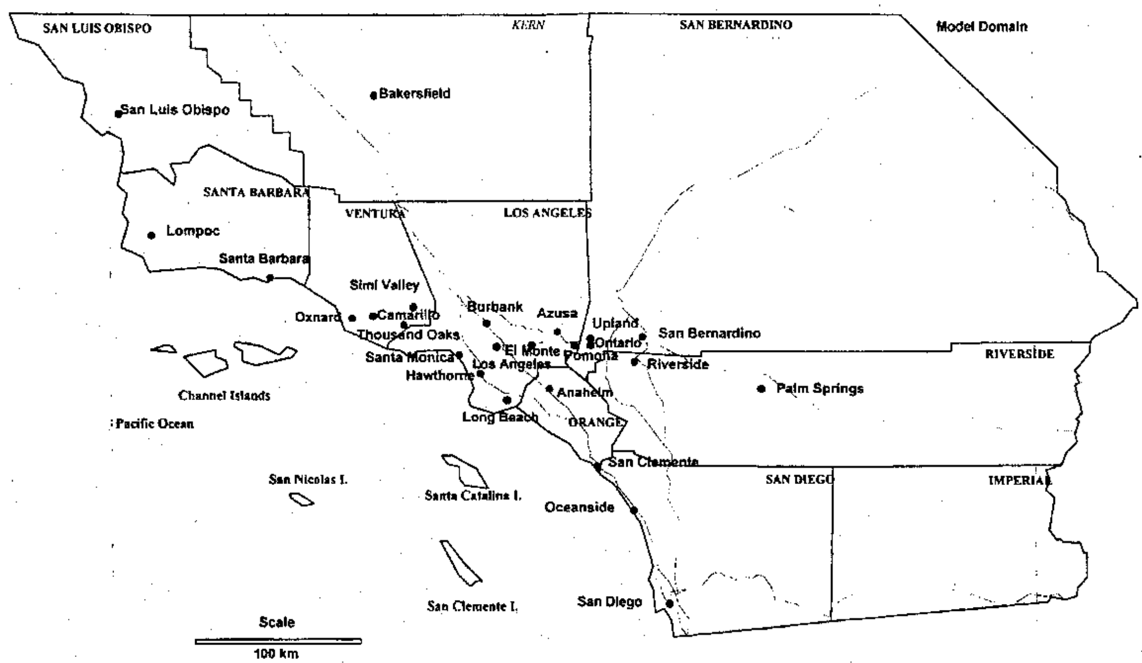

Figure 2-1. The SCOS97-NARSTO study area. Major cities, county boundaries, interstate highways, and the proposed modeling domain are shown.

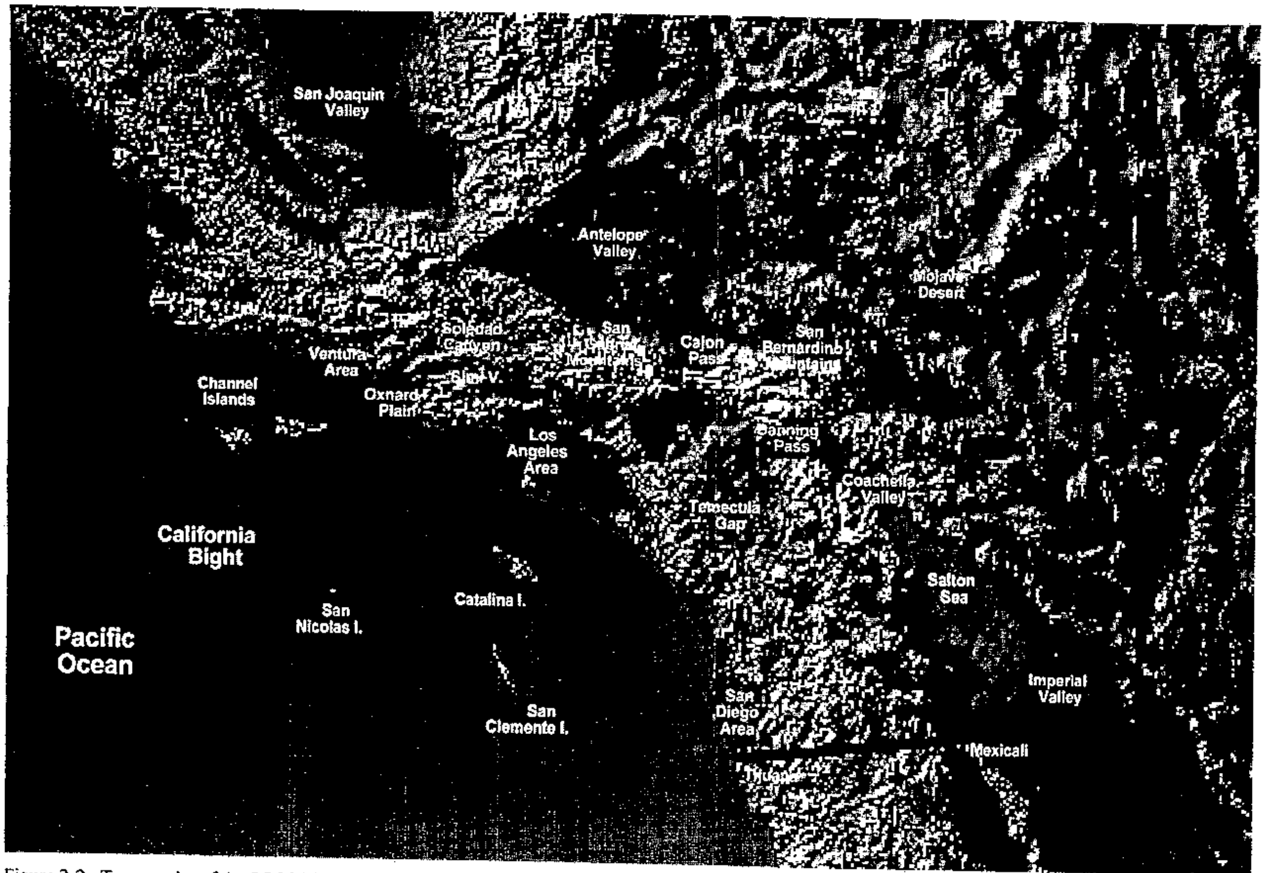

Figure 2-2. Topography of the SCOS97 study area.

Several experiments and data analysis studies examined the relationship of meteorology to air pollutant transport pathways, diffusion, vertical mixing, and chemical transformation in the SoCAB (e.g., Edinger, 1959, 1973; Edinger and Helvey, 1961; Pack and Angell, 1963; Kauper and Hopper, 1965; Schuck *et al.*, 1966; Estoque, 1968; Lea, 1968; Stephens, 1968, 1969; Miller and Ahrens, 1970; Edinger *et al.*, 1972; Rosenthal, 1972; Shettle, 1972; Smith *et al.*, 1972, 1976, 1984; Drivas and Shair, 1974; Angell *et al.*, 1975, 1976; Kauper and Niemann, 1975, 1977; Husar *et al.*, 1977; Keith and Selik, 1977; Blumenthal *et al.*, 1978; McRae *et al.*, 1981; Witz and Moore, 1981; Farber *et al.*, 1982a, 1982b; McElroy *et al.*, 1982; Reible *et al.*, 1982; Sackinger *et al.*, 1982; Schultz and Warner, 1982; Shair *et al.*, 1982; Witz *et al.*, 1982; Smith and Shair, 1983; Cass and Shair, 1984; Smith and Edinger, 1984; Zeldin *et al.*, 1989; Douglas *et al.*, 1991; Bigler-Engler and Brown, 1995;Lea *et al.*, 1995). These experiments and others reveal several general features.

Smith *et al.* (1972), Keith and Selik (1977), and Hayes *et al.* (1984) describe wind flow patterns in the SoCAB. During summer, the sea-land breeze is strong during the day with a weak land-sea breeze at night. Owing to the high summer temperatures and extensive urbanization in the SoCAB, the land surface temperature does not usually fall below the water temperature at night, and nocturnal and morning winds are less vigorous than daytime winds. The land surface cools sufficiently to create surface inversions with depths as shallow as ~50 m. Surface heating usually erodes the surface and marine layers within a few hours after sunrise each day. Summertime flow patterns are from the west and south during the morning, switching to predominantly westerly winds by the afternoon. The land/sea breeze circulation moves air back and forth between the SoCAB and the Pacific Ocean, as well as along the coast to other air basins. Cass and Shair (1984) estimated that up to 50 percent of the sulfate measured at Lennox was due to emissions which had been transported to sea on the previous day. When wind speeds are low, air tends to slosh back and forth within the SoCAB.

In addition to these general features, there are many smaller features that affect the movement of pollutants within the SoCAB. Heating of the San Gabriel and San Bernardino Mountains during the daytime engenders upslope flows that can transport pollutants from the surface into the upper parts of, and sometimes above, the mixed layer. When the slopes cool after sunset, the denser air flows back into the SoCAB with pollutants entrained in it. Convergence zones occur where terrain and pressure gradients direct wind flow in opposite directions, resulting in an upwelling of air. Smith *et al.* (1984) have identified convergence zones at Elsinore (McElroy *et al.*, 1982; Smith and Edinger, 1984), the San Fernando Valley (Edinger and Helvey, 1961), El Mirage, the Coachella Valley, and Ventura. Rosenthal (1972) and Mass and Albright (1989) identified a Catalina Eddy, a counterclockwise mesoscale circulation within the Southern California Bight, as a mechanism for transporting air pollution. This eddy circulation transports pollutants from the SoCAB to Ventura, especially after the SoCAB ozone levels drop due to wind ventilation caused by an approaching low-pressure trough from the northwest. However, any southeast wind in southern California is initially capable of transporting polluted air consisting of ozone precursors and particulate matter from the SoCAB.

General meteorological conditions and trajectories during the 1987 SCAQS episodes have been examined by Douglas *et al.* (1991). Flows during the summertime were westerly, and residence times were often less than 12 hours. The backward trajectories from Claremont and Riverside on August 27 and 28, 1987 show an upper level recirculation in the middle of the SoCAB that probably led to the build-up of ozone and precursors during this episode. Trajectories during SCAQS episodes were consistent with stagnation conditions desired for selecting episodes, and they provide confidence that the SCAQS forecasting methods can be successfully adapted to SCOS97 to evaluate high ozone episodes in the SoCAB. Summer episodes showed west to east transport with potential for pollutant carryover aloft. Forecasting methods for transport from the SoCAB to other air basins, or between other southern California basins, are more problematic and additional work will be needed to improve forecasting procedures.

Green *et al.* (1992a) classified wind field patterns in the SoCAB, San Joaquin Valley, and Mojave Desert during 1984 and 1985 to evaluate visibility reduction in the desert. This analysis evaluated transport between the SoCAB and the Mojave and Arizona deserts. Winds were found to be directly related to the pressure field, which, in summer, resulted from a consistent mesoscale component added to a varying synoptic-scale component. Three main summer patterns were found, all of which had some transport into the SEDAB from the SoCAB. The first, and predominant, pattern indicated typical summer conditions with the wind field driven by the ocean/interior temperature difference and terrain features. The second pattern typically occurred in early summer (May-early June), and had stronger flow into the desert due to synoptic-scale pressure gradients (upper level low pressure over the west coast, surface low over the Intermountain region). This type was also less stable due to cold air aloft. The third pattern showed weaker flow into the desert (and flow from the SEDAB to the SoCAB for a few hours per day) due to higher pressure to the northeast.

The predominant surface wind climatologies for California have been compiled for ARB by Hayes *et al.* (1984) based on 1977-1981 wind data. Figure 2-3 (after Hayes *et al.*) shows seven types of wind flow patterns for the SoCAB and the surrounding air basins. Not shown is an eighth possible condition of essentially calm winds. Table 2-4 gives the frequency of occurrence, expressed as a percentage, of each of these eight wind-pattern types for four times daily during each season. It should be noted that for certain times of day, particularly during the summer, southeast winds may be the predominant wind near and within the inversion (Lea *et al*, 1995; Fisk, 1996a, 1996b).

During summer (June-August) and fall (September-November), the Calm (Type VII), Offshore (Type III), and Downslope/Transitional (Type V) patterns dominate the early morning hours, allowing pollutants to accumulate in SoCAB industrial and business areas. Pollutants then move inland with the Sea Breeze (Type II) in the afternoon hours. However, a period of southeast flow towards Ventura County can occur as the land breeze veers to a daytime sea breeze. While this diurnal sequence is most common during the ozone season, other combinations of wind patterns occur that drive interbasin transport. For example, off-shore surface transport from the SoCAB to San Diego may occur with the Offshore winds (Type III), the Downslope/Transitional winds (Type V), and/or the Weak Santa Ana winds (Type VIa).

2.3 Study Period and Intensive Operational Periods

The SCOS97 field measurement program was conducted during a four-month period from June 16, 1997 to October 15, 1997. This study period corresponds to the majority of elevated ozone levels observed in southern California during previous years. Continuous surface and upper air meteorological and air quality measurements were made hourly throughout this study period. The PAMS monitoring program, which typically operates annually from July 1 to September 30, operated from June 1 to October 31, 1997.

2.3.1 Ozone Periods

Additional measurements were made during intensive operational periods (IOPs) on a forecast basis for two to four consecutive days. Forecasts were prepared each day during the four-month period and IOP measurement groups were on standby. Five categories of meteorological conditions, called scenarios, were defined and are associated with ozone episodes and ozone transport in southern California. Intensive measurements were made during these scenarios. The five scenarios in order of priority as specified by the SCOS97-NARSTO Technical Committee are:

Type 1. *SoCAB Ozone Maximum.* SoCAB pollutants remain trapped within SoCAB. There may be "local" exceedance days for other basins. This condition may be accompanied by a "coast hugger," a near-coast flow of SoCAB pollutants toward the southeast.

Type 2. *Upper-level transport to San Diego Air Basin* Ozone in a layer 300-500 m MSL above the marine layer or above the nocturnal inversion jets southeast toward San Diego. The centerline and width of this pathway are uncertain, and may range from the Interstate 15 route (east) to an off-shore route (west)

Type 3. *Secondary SoCAB Maximum.* An on-shore breeze causes inland transport, with likely transport into the Mojave Desert. This situation may also correspond to local exceedances for Ventura, Santa Barbara, and San Diego Counties.

Type 4. *Coastal Day with Eddy.* This is an extended SoCAB episode that ends with a southeast wind offshore, over the basin, and even sometimes in the desert. It is possibly an extension of Scenario #1 or #2. The ozone peaks are often seen at Newhall or Simi Valley on these days.

Type 5. *Off-shore surface transport direct to the San Diego Air Basin.* This event is characterized by a mild Santa Ana wind condition followed by the on-shore flow. It occurs with greatest frequency later in the ozone season (September-October).

The five meteorological scenarios of interest fall within three overlapping periods which together span the entire ozone season. Types 1, 2, and 3 can occur throughout the summer, but have the highest probability of occurrence in mid-summer. Type 4 typically occurs during the late spring to early summer, while Type 5 occurs from late summer to early fall.

Figure 2-3 South Coast Air Flow Pattern Types

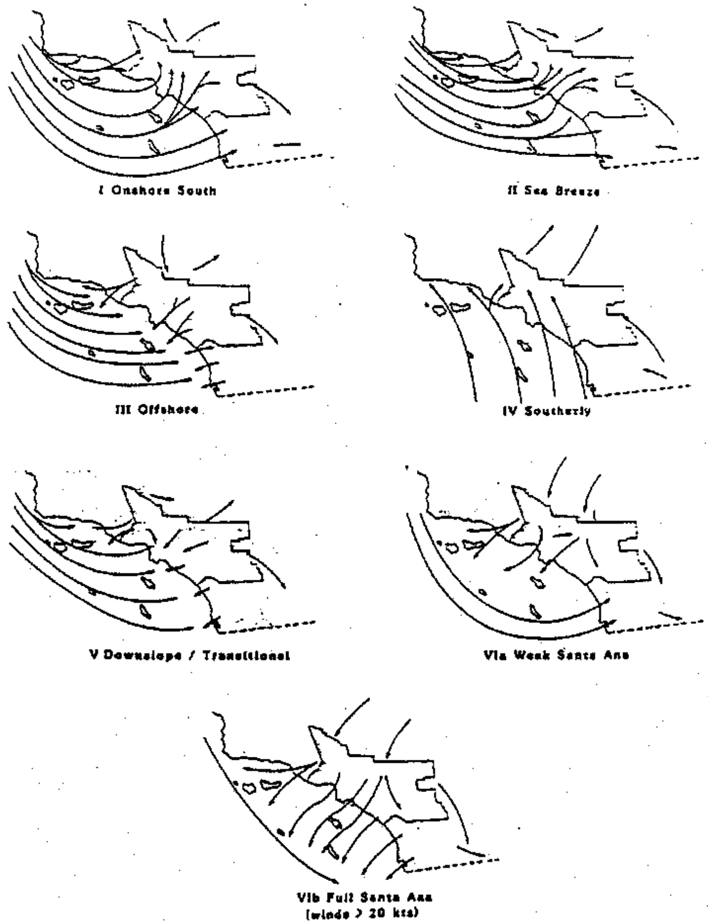

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Table 2-4
South Coast Air Basin Airflow Types
Seasonal and Diurnal Percentages of Occurrence (1977-1981 Data)

Types / Time - PST	I On-Shore South	II Sea Breeze	III Off-shore	IV Southerly	V Downslope/ Transitional	VIa Weak Santa Ana	VIb Full Santa Ana (>20 kts)	VII Calm
Winter								
4 a.m.	3	3	25	3	17	10	7	29
10 a.m.	10	9	16	15	16	12	7	13
4 p.m.	24	51	4	11	4	4	2	0
10 p.m.	6	7	19	7	20	11	7	23
all times	11	18	16	9	14	9	6	16
Spring								
4 a.m.	10	8	19	6	26	4	3	24
10 a.m.	43	29	3	12	5	2	1	2
4 p.m.	31	61	2	4	1	1	1	*
10 p.m.	23	26	9	4	23	3	1	10
all times	27	31	8	6	14	3	2	9
Summer								
4 a.m.	10	5	4	4	34	1	1	37
10 a.m.	51	41	1	6	1	*	*	0
4 p.m.	26	73	0	1	0	0	0	0
10 p.m.	34	39	2	2	18	1	*	5
all times	30	40	2	3	13	1	*	11
Fall								
4 a.m.	7	10	16	2	26	7	4	25
10 a.m.	33	29	5	6	10	6	4	7
4 p.m.	20	67	4	2	2	1	1	4
10 p.m.	16	19	13	2	27	5	3	15
all times	19	31	10	3	16	5	3	13
Yearly								
4 a.m.	8	7	16	4	26	6	4	29
10 a.m.	34	27	6	10	8	5	3	6
4 p.m.	25	63	3	5	2	2	1	1
10 p.m.	20	23	11	4	22	5	3	14
all times	22	30	9	6	14	4	3	12

* < 0.5 percent

2.3.2 Aerosol Periods

The goals of the SCOS97-NARSTO Aerosol Program and Radiation Study were to develop a three-dimensional picture of the generation and evolution of typical late summer and early fall aerosols in the SoCAB, and to provide observations to support modeling of the emissions, meteorological transport and dispersion, and photochemical reactions forming ozone, PM2.5, and PM10. The experimental design focused on ambient sampling along two trajectories in southern California and a motor vehicle particle experiment to test emissions using California fuels, conducted in a tunnel in northern California:

I. A general urban aerosol generation and evolution "trajectory" began in the emissions-rich central Los Angeles area, going to a mid-trajectory site in the San Gabriel Valley, and ending in Riverside.

II. A nitrate dynamics trajectory was run from Diamond Bar, downwind of the most heavily populated portions of the Los Angeles coastal plain, across the ammonia-rich dairying area in the Chino Basin, and ending in Riverside.

III. A sampling program at the Caldecott Tunnel in northern California to measure fine particle size distributions and chemistry to develop source profiles to discriminate between emissions from light-duty (primarily gasoline-fueled) and heavy-duty (mainly diesel-fueled) vehicles.

The SCOS97-NARSTO Aerosol Program and Radiation Study consisted of six interconnected studies: a Trajectory Study, a Tunnel Study, a Fine Particle Measurement Study, a PM2.5 Federal Reference Method Nitrate Loss Study, a Radiation Study, and an Aerosol Aircraft Study. Study dates were generally from August 16 to September 29, 1997 (see Figure 2.3.2-1), with any differences noted below.

Trajectory Study

The Trajectory Study collected continuous aerosol size distribution and composition data simultaneously at three sites. These data will provide the basis for subsequent work to develop, evaluate, and improve photochemical models to simulate the chemical and physical transformations that occur as particles age and travel in the atmosphere. While many of the measurements were made over the entire 6-week period (August 16 to September 29, 1997) of the study, the full suite of sampling was conducted over five 48-hour intensive operational periods (IOPs) selected on the basis of meteorological and air quality forecasts.

The first set of measurements was made at Los Angeles-North Main, Azusa, and Riverside-Pierce Hall, corresponding to a motor vehicle-dominated west-to-east air trajectory along almost the entire length of the SoCAB. Several novel instruments operated continuously for the two-week duration: ATOFMS single-particle analysis and particle size distribution measurements by optical counters and electrical mobility at all three sites, and continuous aerosol nitrate measurements at Riverside-AgOps. Filter-based sampling was conducted during the IOPs (August 21-22, August 26-27) to calibrate the ATOFMS instruments with atmospheric particles and to give further detail on aerosol size and composition. At all three sites, PM2.5 and PM10 composition were measured with 4- to 7-hour-average filter samples for the entire 48-hour period. Micro-orifice impactor samples were collected over one 4-hour period each day at all three sites to determine particle composition in six size ranges from 0.056 to 1.8 µm.

The second set of measurements (September 4-5, September 28-29, October 31-November 1) were conducted at Diamond Bar, Mira Loma, and Riverside-Pierce Hall to focus on nitrate formation along the trajectory.

Tunnel Study

A successful data analysis and modeling effort using the database collected during the Trajectory Study depends on the acquisition of detailed emission source profiles for gasoline- and diesel-fueled motor vehicles. The Caldecott Tunnel east of Oakland is uniquely configured with a center bore only open to passenger vehicles and side bores where trucks are shunted. Thus, the particulate matter concentrations in the center bore are dominated by light-duty gasoline vehicles, and the aerosol burden in the side bores are primarily due to emissions from heavy-duty diesel trucks. During the period November 17 through 21, four experiments were conducted at Caldecott Tunnel

Fine Particle Study

The EPRI-sponsored Fine Particle Measurement Study was conducted at Riverside-AgOps from August 16 to September 22, 1997. Both continuous and 24-hour-average samplers were deployed for the study, with duplicate side-by-side samplers installed when possible. Daily sample changes were made at 10:00 a.m. Pacific Daylight Time (PDT). The continuous aerosol nitrate monitor was operated at Riverside-AgOps during the first two weeks, after which time it was moved to the Mira Loma site.

Comparison of mass and chemical data from continuous samplers (where loss of labile substances is believed minimal) with data from the more conventional filter-based methods (where losses may occur during or after sampling) will begin to characterize the magnitude of measurement error due to loss of labile substances.

PM2.5 Federal Reference Method Nitrate Loss Study

The PM2.5 FRM Nitrate Loss Study was conducted in conjunction with the Trajectory Study. Two FRM samplers were operated side by side at each of the three Trajectory Study sites for the first four experiments. Daily sample changes were made at 1:00 a.m. PDT.

Radiation Study

To test the study design and instrument operation, intensive measurements were initially made on June 29 to July 5, but data recovery at the Mt. Wilson site was incomplete due to logistical and exposure problems. The study began collecting complete data on August 21 when equipment at a new Mt. Wilson site became fully operational. Intensive monitoring on August 27-28 and September 4-6, 10, and 12 was supported by the highly instrumented Pelican aircraft, described in the following section, which provided vertical profiles of irradiance and aerosol size and concentration. Intensive radiation measurements were also made, but without the support of the Pelican, on August 21-23 and October 30-November 1.

Aerosol Aircraft Study

For aerosol and radiation measurements aloft, the Pelican aircraft was operated by the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS), a consortium of the Office of Naval Research, the Naval Postgraduate School, the California Institute of Technology, and Princeton University. Between August 27 and September 13, CIRPAS obtained measurements of the concentrations and size distributions of particulate matter and its constituent chemical species.

A display of the daily maximum 1-hour PM10 [measured with tapered element oscillating microbalance (TEOM)] and ozone concentrations recorded at Riverside-AgOps during continuous and intensive operational periods for the SCOS97-NARSTO Aerosol Program and Radiation Study is given in Figure 2.3.2-1. PM10 concentrations could be much higher than shown because the TEOM is heated to between 30 and 50 ^{o}C to eliminate humidity effects and a substantial fraction of ambient particles can be semi-volatile material such as aerosol nitrate and some organic compounds. It is interesting to note that two of the highest PM10 periods during the study occurred after hurricanes off the coast of Mexico brought large amounts of moisture to the SoCAB. A likely explanation is that formation of aerosol nitrate from gas-phase ammonia and nitric acid was favored under the high relative humidity conditions.

A statistical summary of the 24-hour-average ozone and PM10, and the average of maximum 1-hour concentrations, between August 15 and September 30 of 1995 to 1997, is presented in Table 2.3.2-1. Ozone and PM10 concentrations were about 20% lower in 1997 than the same time period in 1995. This apparent decline could be due to the introduction of California Phase 2 reformulated gasoline in 1996 or meteorological variability. Increased frequency of positive vorticity advection and mid-atmospheric troughing just west of the Pacific Coast (associated with El Niño activity) seemed to contribute to a deeper marine layer and better mixing over the SoCAB during the summer and early fall of 1997.

Preliminary analysis of the data taken at Riverside-AgOps during August 15 and September 30, 1997 show that the PM10 concentrations exhibited an afternoon peak coincident to the ozone peak. Figure 2.3.2-2 illustrates this point for August 22, 1997 with hourly PM10, ozone, and NO_x concentrations. Both PM10 and NO_x exhibited a pronounced morning peak concurrent with low ozone concentrations. The automated nitrate monitor revealed a double peak in the daily nitrate concentration profiles at Riverside. Nitrate concentrations generally increased in the midmorning hours, decreased around noon, and rose again in the afternoon. The relative magnitude of these two peaks varied from day to day.

Table 2.3.2-1. Ozone and TEOM PM10 concentrations, averaged for the time period from August 15 to September 30 for each year (1995, 1996, and 1997) at Riverside-AgOps.

Year	Ozone (ppb)		TEOM PM10 ($\mu g/m^3$)	
	24-hour average	1-hour daily maximum	24-hour average	1-hour daily maximum
1995	42	118	50	101
1996	40	107	45	85
1997	34	95	38	79

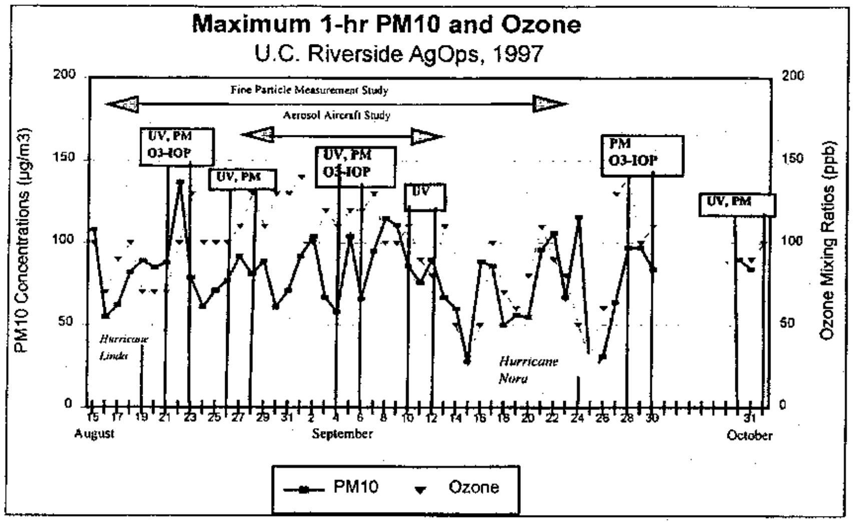

Figure 2.3.2-1. Daily maximum one-hour TEOM PM10 and ozone concentrations during the SCOS97-NARSTO Aerosol Program and Radiation Study with intensive operational periods shown for the Trajectory Study (PM), the Radiation Study (UV), and the Ozone Study (O3-IOP).

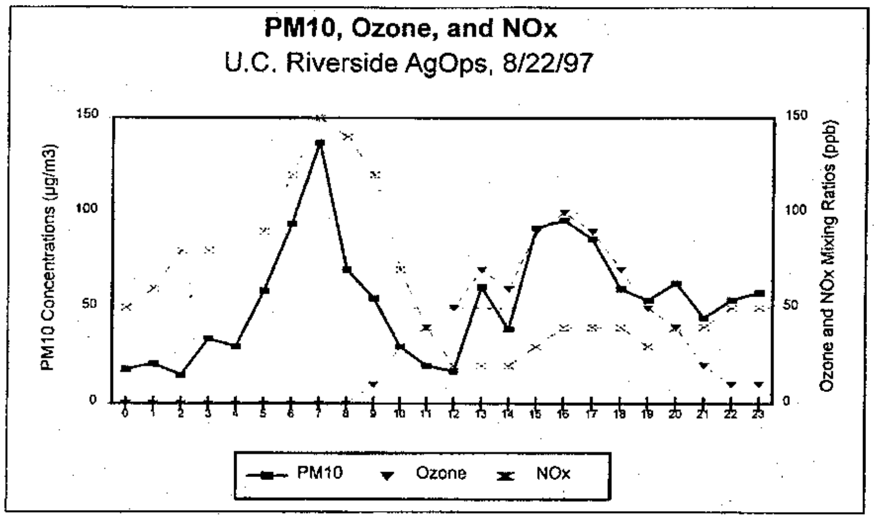

Figure 2.3.2-2. Duirnal profiles of ozone and NO_x mixing ratios at U.C. Riverside-AgOps on August 22, 1997, exhibiting an association with TEOM PM10 concentrations.

2.3.3 Tracer Study Periods

The port of Los Angeles and Long Beach are among the busiest in the world and significantly effect ambient air quality in the South Coast Air Basin. Moving the shipping channel farther off-shore has been suggested as a method to minimize the effects of ship traffic on on-shore air quality. The objective of the tracer study was to evaluate the effects on shipping emissions from moving the current shipping lanes farther from shore.

The tracer experiments were conducted when weak on-shore flows and high ozone levels were expected. These are the conditions where shipping emissions would make their largest contribution to on-shore air quality problems. During the tracer tests three ships released up to five different tracers from locations within the current and proposed shipping lanes. Up to 51 monitoring stations located through out the South Coast Air Basin measured the concentrations of the tracer gases. By comparing the releative concentrations of the five tracers an estimates of shipping emissions effects on on-shore air quality and of moving the shipping lane farther off-shore will be made.

2.4 Forecast and Decision Protocol

To ensure the goals of the SCOS97-NASTO field program were met, it was important that the appropriate air quality episodes were correctly identified. This required that a forecast team be formed to identify and forecast meteorlogical episodes which would lead to the formation of high concentrations of ozone and/or aerosol in the South Coast air basin and subsequent transport to downwind air basins. The forecast team would report their forecast to the field program management committee (FPMC). The FPMC was comprised of representatives from the Research and Technical Support Division of the California Air Resources Board (CARB), U.S. Navy at Pt. Mugu, South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD), U. S. EPA, and Ventura County Air Pollution Control District (VCAPCD). The FPMC would then decide by consensus whether an IOP would be called and notify the field study participants by email, internet home page, and telephone bill board.

2.4.1 Forecast and Decision Protocol - Ozone Periods

The forecast team was comprised of meteorologists from the California Air Resources Board (CARB), U.S. Navy at Pt. Mugu, South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD) and Ventura County Air Pollution Control District (VCAPCD). A two-day minimum notification lead prior to an IOP was needed for equipment preparation and to allow participants to make travel arrangements to Southern California. A day-in-advance confirmation of the predicted meteorological profile and expected ozone was required before the IOP was launched. To meet these needs, the forecast was required to provide a detailed prediction of the same-day, day-in-advance and two-day expected ozone and meteorological profile for Southern California. In addition, each forecast included a three-day prediction to indicate the direction of the ozone trend (either up, down, or continuing) to provide the management team with an estimation of the likeliness of an extended IOP.

The FPMC was required to make a Go/No Go decision by 4:00 p.m. PDT daily. To meet the FPMC's needs the forecast needed to be prepared by 3:00 p.m. A 2:30 p.m. PDT daily conference call was scheduled to bring together the forecast team to finalize the forecast. The 2:30 PDT forecast time was selected to provide the individual forecast teams with access to the evolving ozone trend and the latest output from the 0500 PDT (1200 UTC) National Weather Service (NWS) numerical model simulations. The forecast discussion was conducted in three phases: (1) weather discussion and preliminary forecast, (2) group discussion and consensus forecast modification, and (3) extended outlook. Prior to the discussion, a preliminary forecast based on the SCAQMD objective model was faxed to each of the forecast groups along with an initial forecast summary. The forecast team members held discussion until a consensus was reached or a failure to agree was logged. The decision was then finalized and relayed to the FPMC.

The FPMC would then reach a consensus on whether to call an IOP. The IOP decision announcements were as follows:

- **"Possible-Go"** (or "No-Go") would be posted by 4 p.m. for an IOP start 35 hours later.
- **"Definite-Go"** (or "No-Go") would be posted by 11 a.m. for an IOP start the next morning at 0300 (midnight for the SCAQMD) for speciated VOC sampling and 0500 for rawinsondes. Under some, hopefully rare, circumstances the "Definite-Go" decision would be postponed until 4 p.m. that day, in which case the 11 a.m. posting would be for a "Possible-go".
- **After an IOP has started**, the second, third, and fourth days are automatically "Possible-Go". "Definite-Go" or "No-Go" decisions for each successive IOP day would be posted at 11 a.m. the day before, with the possibility that the decision would be postponed to 4 p.m.
- **Once a "No-Go" decision is posted, it will not be changed.** A "Definite-Go" decision would only be changed if the predicted meterological situation totally collapsed. In this case, each measurement group would be notified individually.

2.4.2 Forecast and Decision Protocol - Aerosol Periods

Over the entire 6-weeks period (August 16 to September 29, 1997) the trajectory study, aircraft study, and FRM nitrate loss study relied on forecasts from the SCAQMD for selecting the best two days (PM episode) of the upcoming week for intensive sampling.

In general typical meteorological characteristics of a high PM10 day in the SoCAB include: a well developed upper-level ridge of high pressure, strong elevated subsidence inversions, low level stratus and fog, and a nearly neutral surface and boundary layer wind field. However, increased frequency of positive vorticity advection and mid-atmospheric troughing just west of the Pacific Coast (associated with El Niño activity) seemed to contribute to a deeper marine layer and better mixing over the SoCAB during the summer and early fall of 1997.

Two consecutive days of measurements were made each week, chosen in consultation among Professors Glen Cass and John Seinfeld of Caltech, Joe Cassmassi of SCAQMD, professor Kim Prather of U.C. Riverside, Dr. Susanne Hering of ADI, and Mr. Tony VanCuren of ARB.

"Go" Decision Protocol and Announcements

- Each day, by 3 PM, the group made a "No-Go" or "Probable-Go" decision for aerosol measurements commencing in 34 hours. Once a "No-Go" decision was made, it could not be changed.
- If the following day was a "Probable-Go", the group made a final "No-Go" or "Definite-Go" decision for aerosol measurements by 11 AM.
- Each day, by 3 PM, the ARB posted the decision on the phone machine and with an e-mail message.
- The 2-day IOPs were at least 2 days apart.
- The preference was to have at least one 2-day IOP each week.
- Intensive sampling periods could occur on a weekend, if it was the time period of high PM concentrations.

2.5 Summary of Ozone Intensive Operational Periods

Six Intensive Operational Periods (IOPs) were called during the 1997 Southern California Ozone Study which was conducted in coordination with the North American Research Strategy for Tropospheric Ozone (SCOS97-NARSTO). The first IOP was cut short (lasted only one day) due to the unanticipated high clouds from a hurricane south of the study area. Three other IOPs had partial deployment of resources on the day before or after the IOP to better characterize the full ozone episode. A summary of the IOPs, Table 2.5a, provides information on the dates, day-of-week, type of episode, maximum 1-hour and 8-hour ozone concentrations by sub-areas, aircraft activities, and concurrent aerosol or tracer release activities. The air quality concentrations noted are based on preliminary data and are subject to change. Intensive Operational Days for aerosols occurred on five ozone intensive days during three ozone IOPs. The three offshore tracer releases also occurred during three ozone intensive days. Exceedances of the national ambient air quality standards for ozone occurred during all six episodes.

To provide the context of the IOPs during SCOS97-NARSTO, Table 2.5b and Figures 2.5a-f are included in this summary. The Table and Figure provide the daily maximum 1-hour and 8-hour ozone concentrations observed in each air basin within the SCOS97-NARSTO modeling domain from June 15 through October 16, 1997. These summaries are based on data residing on the U.S. EPA's Aerometric Information and Retrieval System (AIRS) on March 26, 1998. It is noteworthy that the ozone episodes that occurred during the long Independence Day weekend had among the highest, if not the highest, 1-hour and 8-hour ozone concentrations for the study period.

The following subsections briefly describe the meteorological and air quality conditions observed during each of the IOPs. In principle, the following non-routine measurements were made during each day of an IOP:

1) four 3-hour samples each of volatile organic compounds (VOC) and carbonyl compounds (C=O) at 18 sites (two 12-hour samples were taken at the three background/offshore sites)
2) peroxyacetyl nitrate measurements at Simi Valley and Azusa
3) lidar measurements at two sites (ozone and aerosol scatter at El Monte AP on ozone IOPs and several aerosol IOPs; ozone aerosol scatter, water vapor, and temperature near Hesperia between August 23 and September 19)
4) four ozonesonde releases (at 0800, 1400, 2000, and 0200 PDT) each day from 7 sites (Anaheim, California State University at Northridge, Pomona/Upland, Point Mugu, Riverside, University of Southern California, and Valley Center
5) four rawinsonde releases (at 0500, 1100, 1700, and 2300 PDT) each day from 12? sites (Bakersfield, China Lake Naval Air Weapons Center, Edwards AFB, Imperial Beach, Miramar Naval Air Station, North Island Naval Air Station, Pt. Mugu Naval Air Weapons Center, San Nicolas Island, Tustin, Twentynine Palms-Expeditionary Air Field, University of California at Los Angeles, and Vandenberg AFB
6) multiple flights per day by up to six aircraft
   a) Aztec - northern boundary and trans-basin in SoCAB; also back-up for Navajo
   b) Navajo - western boundary and offshore
   c) Partnavia - offshore

d) San Diego Cessna 182 - southern domain
e) UCD Cessna 182 - central SoCAB
f) Pelican - SoCAB aerosol characterization (flights coincided with ozone IOPs only on September 3-6)

Occasions when measurements did not occur as planned during an IOP are noted in discussion.